DISCOVERY

A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY A. S. RUSSELL, M.C., D.Sc.

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Editorial Notes

Those who are in favour of changing our present coinage system for a decimal one will not view with especial favour the recent report of the Royal Commission on Decimal Coinage. It is not a unanimous report, but two-thirds of the members of the Commission are against making a change in the present system. It is felt that the obvious advantages to be gained by changing to a decimal system—as, for example, in keeping accounts—are outweighed by the disadvantages arising from the loss of convenience of the present system for other purposes. If a change must be made, the Commission thinks that the pound-mil scheme is the best.

In this scheme the pound sterling remains as in the present system. It is not altered in any way. The farthing is altered slightly in value, however, so that instead of 960 there are 1,000 of them in the pound. These new coins would be called mils. One hundred mils would be equivalent to the present florin, and ten of them to a new coin approximately equal to twopence-halfpenny.

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There is no question that, if everybody in the country would agree to drop the present system, forget all about it, adopt a decimal system and acquire ability in using it in a very short time, the change would be one for the better. But it is, of course, a much simpler thing to condemn the present system and to devise a decimal one, than to suggest a means of "switching over" from the old to the new without causing inconvenience that in many cases would be little short of chaos. It is a change, however, that ought to be made sometime, and it appears that the adoption of a decimal system of weights and measures throughout the country would prepare the way to some extent for the adoption of a similar system of coinage.

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Direction-finding by wireless waves has now been brought to a considerable degree of perfection. The apparatus used for this is called the wireless direction-finder. When a ship loses its way through fog, or owing to any reason, this instrument provides a means whereby the captain can get into touch with wireless stations on land or on other ships, and know in a few minutes just where he is. Recent Admiralty orders have provided for the establishment of wireless stations on the coast, which will work in conjunction with these direction-finders. The Marconi direction-finder not only receives wireless signals; it also indicates the direction of the sending station.

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It has a working range of from 200 to 300 miles as ordinarily employed, and it is unaffected by weather conditions. In wireless telegraphy, as is well known, the signals are transformed into sounds by the receiving gear, and these are heard by the receiving operator, who wears a telephone headpiece for the purpose. If we imagine ourselves "listening in" in this way on board ship in the English Channel, we should hear all the ships and shore stations in the neighbourhood that happen to be working at the moment. By means of the direction-finding apparatus a bearing to the source from which the wireless waves are coming may be obtained. By finding the bearings to two or more stations whose positions are known, the ship's position on the chart may be found. Suppose, for example, that a ship coming up the English Channel in foggy weather is somewhere to the west of the Channel Isles. It could ascertain its position by taking bearings on Land's End and Ushant, and a

third reading on Cherbourg, provided that a check on these observations is required. Under the conditions the direction-finder indicates that Land's End is somewhere on a line making an angle of 66 degrees with the fore and aft line of the ship, and the corresponding angle for Ushant is 5 degrees. The direction in which the ship is heading at the moment of the experiment is known, since it is given by the compass, and it is therefore not a difficult matter to combine observations and set out the ship's position on the chart.

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It may be mentioned that it is not always necessary to ascertain the ship's position, the direction of a known point from the ship being often all that is needed. In such cases one observation only is necessary, as, for example, in determining whether a ship's course will take it inside or outside a lightship or isolated lighthouse. A wireless signal from one or the other will settle the question almost as certainly as though the lights were visible. Again, when the ship is about to enter harbour, signals from a station in the harbour will show immediately if the ship has drifted to one side of the entrance.

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An interesting point bearing on the truthfulness of novelists is dealt with by Mr. H. M. Paull in a recent number of the *Fortnightly Review*. Mr. Paull points out that it is a not infrequent practice for an author to write an introduction to his story in which he gives deliberately an erroneous account of its origin. Defoe, for example, informed his public in the preface to his *Journal of the Plague* (1722) that this work was really written by a man who continued all the time in London while the Plague was raging. As Defoe and no other was the author, and as he was only two at the time of the Plague, it is evident that his idea of truth is—well, is simply not truth at all. Scott, Goldsmith, Horace Walpole, and in more recent times George Gissing, are also cited as sinning in this way. It is, however, not a common practice. Those who write these fictitious prefaces generally do so for reasons similar to those which lead writers to adopt *noms-de-guerre*, but in a few cases the motive is less worthy. Some authors find that a certain kind of showman's lie in the preface helps the sale of their books, others do it for the pure intellectual joy of lying.

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In subsequent numbers of this journal we hope to make a new departure in having pictures and diagrams illustrating the articles. In the next number we hope to print articles on St. Francis, the Recent Discoveries in Crete, the Origins of Mexican Mythology, Air-Routes of the Empire, Aviation and the Postal Service, Beet and Industrial Alcohol, and on other subjects.

The Concert of Europe in the Nineteenth Century

By F. J. C. Hearnshaw, M.A., LL.D.

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(*Continued from April No., p.* 108.)

IV

ALTHOUGH by 1830 the Quadruple Alliance was quite broken up, and although its members found themselves ranged in antagonism to one another on several fundamental issues, yet even then the tradition of common interests and common action established during the Napoleonic era and the period of the Congresses was never again wholly lost. From 1830 right down to 1914 the Concert of Europe, albeit it ceased to give continuous performances as during the years of its glory, never went entirely out of existence. On the contrary it maintained a useful vitality ; it enlarged its membership ; it made it a particular business of its own to deal with the Eastern Question and other acutely controversial problems of international politics; it succeeded in preventing several wars; it managed to effect more than one important world-settlement.

First, as to its members. The four Powers of the old Quadruple Alliance continued to occupy the position of prime importance. Next, and almost equal to them, came France.[1] Italy was admitted in 1859. In 1871 Prussia brought the newly constituted German Empire with her into the innermost circle of the elect, and began to claim in her name a hegemony. For purposes extra-European—with which we are on this occasion not concerned—the United States and Japan began to be included. When problems of world politics came into question, the States of Asia and Southern America were increasingly asked to send delegates : thus at the first Hague Conference twenty-six Powers were represented ; at the second, forty-two.

It did not prove easy for Powers so numerous and so diverse to co-operate for common ends. Each of them had its own particularist interests which it pursued in preference to those of the community of States. These particularist interests tended more and more to clash with one another, especially in the spheres of economic and colonial expansion. The associated Powers, moreover, represented and embodied conflicting political principles, and it became increasingly hard for those which stood for democracy and nationality to work in harmony with those that were inspired by ideas of military autocracy and world dominion. From 1871 in particular, the youthful German Empire,

[1] Under the Emperor Napoleon III, indeed, France for a few years, especially 1856–60, rose to a position of ascendancy.

with its ambitious aims and its intolerable manners, became an almost insuperable obstacle to any cordial co-operation among the Powers, or to any continuance of honest understanding and genuine goodwill.

It is remarkable that in such circumstances the Concert of Europe could continue to exist, and still more that it could do any good and effective work. That, in spite of all, it did exist and that it achieved some notable successes is eloquent testimony to the sense of solidarity which still held the Continent together, and to the skill and patience of the diplomatists who accomplished so much in conditions so unfavourable. To enter into details concerning its operations would lead us too far afield into the minutiæ of European history. It must suffice to say that on at least ten occasions the Powers acting in concert dealt with and settled (if only provisionally and temporarily) questions which, apart from their action, would in all probability have led to a Continental conflagration. The following is the summary list of these occasions, which is all that can be presented here and now. Particulars can easily be filled in from the *Cambridge Modern History* or other convenient textbooks. (1) The revolt of the Greeks from the Turkish suzerainty, that at one time seemed likely to embroil Russia with Austria on the one side and Britain on the other, was finally settled by Conference at London, and this in spite of the fact that Austria and Prussia refused to send representatives, thus leaving Russia, France, and Britain to find the path of peace. The problem was solved by 1833, when independence was secured, boundaries delineated, and a kingdom under Otto of Bavaria set up. (2) The separation of Belgium from Holland in 1830 gravely threatened a general European war. For not only did William of Orange refuse to recognise the disintegration of his kingdom; he was supported by his brethren of Russia, Austria, and Prussia. The good instances of France and Britain resulted in the settlement of the conflict by diplomatic means, and in 1839 the final partition was peacefully accomplished. (3) In 1840 the Near Eastern question once more disturbed the Christian Powers of the West. Mehemet Ali of Egypt rose in revolt against his sovereign the Turkish Sultan. France, then in search of glory under the guidance of Thiers, lent him encouragement and support. A series of striking military successes gained by Mehemet and his warrior son seemed to portend the dissolution of the Turkish Empire. The four Powers—Russia, Austria, Prussia, Britain—however, by timely and decisive intervention, saved the Sultan from ruin, forced France to withdraw her support from Mehemet and to abandon her neo-Napoleonic policy in the East. Whatever may be said as to the ultimate righteousness and wisdom of the policy of the maintenance of the integrity of the Turkish Empire, there can be no doubt that at the moment the action of the Quadruple Alliance prevented a gigantic upheaval. (4) In 1852 a menacing problem relating to the Danish succession was dealt with and solved amicably in a Conference held at London, and attended by representatives of the five Great Powers, together with those of Norway, Sweden, and Denmark. (5) In 1856 the status of Serbia and Rumania, both of which had secured virtual independence, was treated and decided at Paris by plenipotentiaries from the five Powers, plus Sardinia and Turkey. (6) The very formidable question of the position of Luxemburg, which in 1867 seemed likely to precipitate the Franco-Prussian War, was referred to a Conference of diplomats representative of the five Powers together with Italy (now the sixth Great Power), Holland, and Belgium. The Conference successfully dealt with the thorny problem, and arrived at that treaty settlement of neutrality which regulated the status of Luxemburg as a buffer-duchy down to the outbreak of the war of 1914. (7) In 1884 the Powers, in conference at Berlin, removed Africa from the sphere of probable conflict—into which it had been brought by the sudden outburst of German colonial activity during that year—by carefully partitioning it into zones of influence. (8) In 1900 they did the same for Oceania. (9) In 1906 they obviated a Franco-German struggle respecting Morocco; and, finally, (10) they postponed the Great War for a few months by their London agreement concerning the Balkans in 1912–13. These are achievements of no mean magnitude, and they need to be taken into account and carefully weighed by those who tend to talk too readily about the "European Anarchy" of modern times. There was a good deal more "International Government" in Europe during the nineteenth century than some political critics are disposed to allow. It was, however, it may be freely admitted, of a very imperfect and rudimentary kind. If it was strong and effective enough to prevent wars on ten or more occasions, it failed to do so on at least five others.

V

The wars which the Concert of Europe failed to prevent during the nineteenth century were, first, the Crimean War of 1854; secondly, the War of Italian Liberation, 1859; thirdly, the wars for the unification of Germany and the aggrandisement of Prussia, 1864, 1866, 1870; fourthly, the Russo-Turkish War, 1877; and, finally, the German War for world dominion, 1914. In each case strenuous efforts were made by the Powers not primarily concerned to mediate, to arbitrate, to compose the causes of quarrel by negotiation, to secure the calling of Conferences and Congresses. In each case these efforts failed, and we can now clearly

discern why they failed. The issues at stake were too great, and of too vital an importance to one or more of the States involved, to be settled by any of the feeble and ineffective organs which the Concert of Europe had then at its disposal. The deep causes of these unprevented and (in the circumstances) almost inevitable wars were broadly one or other of two; they may be briefly distinguished by the labels "national" and "imperial." The Italian war of 1859 was a national war. It was necessary to expel the Austrians from the peninsula, and in the middle of the nineteenth century there was no means of doing it except by fighting. Such a gigantic task was quite beyond the competence of the then existing Concert of Europe. To prevent in the future such a war as that of Italian liberation a "League of Nations" will have to possess immense legislative and executive powers. Similarly the Prussian wars of 1864–70 were national. The grand issue, foreseen by Bismarck and his associates, was the unification of Germany under the Prussian hegemony. The attempt to effect this end by constitutional and parliamentary means had conspicuously failed in the years 1848–52, and Bismarck had clearly perceived and plainly said that "not by speeches and resolutions of majorities are the mighty problems of the age to be solved, but by blood and iron." The unification of Germany under the Hohenzollerns necessitated on the one hand the extrusion of the Hapsburgs, and on the other the destruction of the hostile empire of Napoleon III. In the existing condition of things nothing but war could accomplish these requisite tasks. So, too, nothing but war could in 1877 secure the emancipation of the Bulgarian nation from the Turkish yoke. National problems like the Italian, the German, and the Bulgarian involved political disintegration and reconstruction of so radical a character as to baffle all the resources of nineteenth-century diplomacy. The Concert of Europe could do much to preserve peace by the maintenance of the *status quo*: it could do little or nothing to preserve peace by the diplomatic facilitation of the transition to the *status ad quem*. So much for the national causes of the great nineteenth-century wars. The other leading cause was imperial ambition—an ambition not limited to an imperial ruler, but shared by an imperial army, and supported and applauded by an imperial people. The Crimean War—one of the most unnecessary and futile conflicts in the world's history—was forced upon a reluctant but bewildered Europe by the insane lust for military glory which possessed Napoleon III, and by the unyielding pride and obstinacy of Nicholas I of Russia. Mediation and persuasion were lost upon autocrats of the temper of these two. Behind them, however, were two nations each of them infected by the belligerent passions that made the foolish struggle unavoidable. Thus, too, was it in 1914. In vain did Sir Edward Grey and his colleagues exhaust the resources of conciliation to prevent the outbreak of the world war. German imperial ambition had deliberately prepared the conflict, and no human power then extant could avail to stop it or postpone it. And behind the German Emperor stood the German army eager for the long-anticipated "fresh and joyous fight," while behind the German army, and confident of its invincible power, stood the German nation waiting to exploit the earth. Against such a formidable imperial "will to war" the Concert of Europe was helpless. If in future a "League of Nations" is to be effective in similar conditions, it will need to be very strong indeed, and very quick in action.

VI

Both the successes and failures of the nineteenth-century Concert of Europe are instructive. Its very considerable successes point the path along which the nations may securely tread towards that goal of perpetual peace which they now so ardently seek to attain. They show that problems of all kinds are amenable to peaceful settlement; that a body of international morality and custom exists which may easily be raised to the rank and efficacy of law; and that a good deal of international machinery has been created which can do much more effectively and much less wastefully the work that has too often been assigned to guns and bombs. The failures of the Concert, on the other hand, indicate that, if all wars in the future are to be obviated, there is need of an international authority strong enough on the one hand to crush all efforts of imperial ambition to extend its own dominion, and on the other hand to handle and solve the insistent problems raised by national consciousness and desire—strong enough to satisfy legitimate national demands even at the cost of the disintegration of old-established states; strong enough to resist and refuse the unreasonable demands of pseudo-nationalities. The Concert of Europe failed in the crucial cases because of its lack of real unity; because of the particularism of its members; because of its want of legislative, executive, and judicial authority. If a "League of Nations" is to succeed where the Concert failed, there must be congruity among its members—i.e., they must all be democratic States which accept the same general principles of representative government; they must bind themselves in a close and permanent alliance in the full consciousness that in doing so they are each of them surrendering into the common stock a large measure of their former independence and sovereignty; and they must maintain not only the necessary legislative, executive, and judicial organs of international government, but also armed forces capable of suppressing disorder and enforcing the general will.

The Origin of the Solar System

By Harold Jeffreys, M.A., D.Sc.

Fellow of St. John's College, Cambridge

How is it that the earth can keep its atmosphere? We know that when a person smokes in one corner of a room it is only a few seconds before the smell is noticeable all over it; and that when a small amount of a gas is let into a chamber from which the air has been exhausted, it expands in a fraction of a second so as to fill it completely. Yet the earth's atmosphere, with a more perfect vacuum outside it than any we can make, manages to persist for thousands and even millions of years. Why does it not spread out and become lost to us? The answer illustrates one of the most important principles in modern theories of the origin of the solar system. If a body is thrown up, it falls down again; but if it was thrown with more than a certain "critical" velocity, about 11 kilometres (7 miles) per second, it would not return to the earth at all; it would travel off into space and revolve round the sun. Now a gas consists of a vast number of small particles, called molecules, rushing about in all directions with different velocities; their average velocity depends on the constitution of the gas and on its temperature, but is in terrestrial conditions always of the order of a kilometre per second. Individual molecules may, however, attain much greater velocities. If, then, a molecule on the outskirts of the atmosphere attains the critical velocity, it passes off into space, but not otherwise. At the present time this rarely happens; our atmosphere is being lost so slowly that it will be billions of years before any change is appreciable.

We know, however, that the earth is very hot inside, and there is very strong geological reason to believe that it is a cooling body, and that a long time ago it was actually liquid at the surface. But that may not have been the start; before that it may have been largely, perhaps wholly, gaseous. In these circumstances it must have been much larger in size than it is now, and this would cause the critical velocity to be less. On the other hand, the high temperature would make the velocities of the molecules of the air greater, and it would on both accounts have taken the air a shorter time to be lost. But our atmosphere may have come since then from the inside of the earth, in the form of volcanic gases, and have been gradually altered in composition by living organisms. We can go further, however. The iron and silica that constitute most of the earth must have been vapour then, and we can show that these must have been lost had the earth had more than three times its present radius; and then there would have been no earth left. In fact, whatever we suppose to have been the origin of the earth, whether solid, liquid, or gaseous, it can never in any circumstances have had a specific gravity of less than $\frac{1}{5}$. The larger planets, on account of their greater masses, could hold together when much more widely distended; but the smaller bodies of the system, such as the asteroids and most of the satellites, would have been dispersed for much smaller distensions. In fact we can show that these can never have been gaseous at all, and must therefore have been solid or liquid ever since they had a separate existence.

The theories of the origin of the planets fall into two classes. In the older theories (those of Laplace, Roche, Faye, and Lockyer, for example) the formation was supposed to be by some process of gradual condensation from a more or less symmetrical gaseous or quasi-gaseous mass surrounding the sun. The above argument shows that these are untenable. The matter near the earth must have had a density of at least $\frac{1}{5}$, otherwise it could never have condensed at all; and as the sizes of Mercury and Venus are still less, we see that the density nearer the sun must have been greater than this. When we calculate what the mass of the matter within the earth's orbit must have been on this basis, we find that it must have been at least a million times what the mass of the sun is now. There is no way in which such a mass of matter can have left the system, and accordingly these hypotheses must be abandoned.

The condensation must therefore have taken place from a very limited region, occupying not more than a millionth of the volume of the solar system. Yet it must have extended from Mercury to Neptune. A mass of this extreme length and thinness could not possibly last more than a few years without breaking up; it must therefore have been suddenly formed, and broken up into the planets soon afterwards. In a long and detailed investigation Jeans has recently shown that such a filament could have been produced in only one way. When the sun was largely gaseous and much distended, a star considerably more massive than itself must have approached. The sun's envelope became egg-shaped, the sharp end pointing towards the star, and when the star came near enough this end became actually pointed. At this stage the tendency to disruption produced by the star just balanced the sun's tendency to hold together on account of the mutual gravitation of its parts. With a slight further approach the point opened into a gap, and out of it poured the gases of the envelope, slowly at first, more rapidly as the star came nearer, and slowly again as it receded in its hyperbolic or parabolic orbit. The filament shot off was therefore thickest in the middle. As the star passed on it attracted the filament towards

it, with the result that the whole was given a motion of revolution around the sun in the plane of the motion of the star. This narrow gaseous body could not, however, remain long unaltered. It can be proved that any such body must in time break up into a row of fragments on account of the mutual attraction of its parts. Thus the planets were formed, and on account of the variation in thickness the largest were at the medium distances from the sun. At the same time cooling would take place, partly owing to increased radiation from the extended surface, and partly because it would tend to expand under the low pressure; for expansion leads to cooling. (To observe the opposite effect due to compression, pump up a bicycle tyre quickly and see how hot the pump gets.) Thus much of the matter in it would soon liquefy. In this way a number of planets of varying sizes would be formed, the largest in the middle, and all moving in one direction, and nearly in one plane; the largest would be mostly or wholly gaseous, and the smaller ones liquid. The resemblance to the actual solar system is obvious; for Jupiter and Saturn, the largest planets, are at medium distances from the sun, and appear to be still partly gaseous, and all the planets do move nearly in the same plane. The smaller ones have of course solidified since. Thus the theory that was adopted, because it was the only one that could account for the existence of the smaller bodies of the system, accounts immediately for several other striking features. But its success does not end there.

Not all the ejected matter could collect to form the planets. Much of it quickly spread out through the system before it had time to condense; this became a very rarefied gaseous mass, filling the whole of the system at least as far out as the orbit of Neptune. It was in motion to start with, and each part of it would continue to revolve round the sun as the planets do.

The primitive planets would move in very eccentric orbits, passing near the sun at one part of their revolution, while their furthest distances would be very great. In moving to and from the sun like this they would experience a great resistance from the gas they were travelling through. Hence this motion would gradually be damped out, and the planets would come to move in nearly circular paths, as they do now. At the same time the medium itself would be altered. It would always be tending to spread into outer space, just like a planet's atmosphere, and would therefore be gradually lost. This would be accelerated by the friction of the planets moving through it, which would keep the temperature high. The matter causing the zodiacal light is probably the last remnant of it. The great planets would, by their gravitation, collect large masses of compressed gas about them; these would move with them, thus very much increasing the surface that was being pushed through the medium. This surface would in fact be almost proportional to the square of the mass of the planet, and consequently the larger the planet the more would its orbit be altered by friction. This agrees well with the present eccentricities. The four great planets have small eccentricities, and the largest eccentricities are those of the smallest planets, Mercury and Mars. The earth and Venus have even smaller eccentricities than Jupiter, but this is only temporary; it is known that their eccentricities oscillate within wide limits.

The formation of the satellites is more difficult to trace, not so much on account of any inconsistency with the theory as on account of the variety of methods, all consistent with the theory, that often offer themselves in particular cases. We shall consider these in turn.

When the planets approached the sun very closely at their nearest points (their "perihelia"), the sun must have raised great tides in them, and this may have caused filaments of matter to be shot out in the same way as the approach of the star caused a filament to be shot out of the sun. In the case of the great planets this caused systems of satellites to be formed, each satellite system resembling the solar system as a whole in that the largest satellites would be at the medium distances, all would revolve in the same direction and approximately in the same plane, and the eccentricities of their orbits would gradually come to be small. This is true of the satellite systems of all the outer planets, except that the outermost satellite of Saturn and the two outermost of Jupiter revolve in the opposite direction to the others. Also the direction of the revolution should be the same as that of the revolution of the planets; but the four satellites of Uranus revolve in a plane at right angles to this, and the one satellite of Neptune revolves in nearly the opposite direction. These are difficulties that await solution.

Some of the satellites, however, may be as old as the planets. If a small nucleus in the original filament happened to be near a large one when it was formed, it might have continued to revolve round it ever since. For this to happen it must have been a long way off, so that it would not get involved in the dense matter that afterwards condensed into the planet. Now, it appears that if a satellite is at a great distance from its primary, it is least disturbed by the sun's attraction if it moves round the primary in the opposite direction to the usual one. Thus when a satellite in a direct orbit would suffer great perturbations, and perhaps be forced ultimately to leave its primary altogether, one of these "retrograde" satellites might survive. This may be the origin of the retrograde satellites of Jupiter and Saturn, which are so much more remote from their

primaries than the furthest of the others that there seems to be a fundamental difference between them. Further, as they were not within the compressed gas around the primaries, their eccentricities would not have altered much; and actually they have very large eccentricities.

The anomalous satellites of Uranus and Neptune are in a different position again, for they are comparatively close to their primaries. There is no quite satisfactory explanation of their remarkable motions. Perhaps for some reason, as yet unknown, Uranus and Neptune acquired abnormal rotations from the start (and the retrograde satellites of Jupiter and Saturn suggest that there was something peculiar about the local motions at the outer end of the original filament), and either by tidal action, or by forcing the medium near them to rotate with them, caused the orbits of their satellites to turn round till the satellites revolved nearly in the equatorial planes of the primaries.

The moon may have been a primitive nucleus like the retrograde satellites of Jupiter and Saturn, but it is not very likely, for several reasons. In the first place, it is certain that the moon has been receding from the earth for ages, and when the oldest known sedimentary rocks were laid down it must have been very much nearer than it is now. This follows from the facts known about tides in shallow seas, and is confirmed by two results of observation. If from the data we have about the moon we calculate its position at some past time, some thousands of years ago, it is found that its observed position then was somewhat further west, and the difference is nearly such as would be expected from the theory of the tides. Again, certain facts about the shape of the moon indicate that it did not become solid when at its present distance, but at about a third of it. It is unlikely that two separate nuclei were formed at such a short distance apart, so that the moon was probably initially part of the earth.

If the primitive earth-nucleus was broken up by tidal action in passing near the sun, the change would not have taken place in the same way as was suggested for the great planets. The earth was much more dense than these, and was probably largely liquid from the start. Now, a liquid or solid body broken up by tidal action would not eject a long filament and form a series of satellites: it would break into two pieces, one large and one small, very much like the earth and the moon. I do not, however, think that the moon was formed in this way. If a body was once broken up like this, there is no reason why it should not happen again and again, forming in succession four, eight, sixteen, and more pieces, until the bits were so small that they cooled and solidified, when their cohesion might afterwards hold them together. The solar system actually seems to contain two examples of this. The rings of Saturn are composed of many tiny bodies, and are generally believed to be the result of the destruction of a satellite in this way. Also the asteroids may have been formed from a primitive small planet, broken up by approach to the sun, or more probably to Jupiter, in view of the large eccentricities of some of their orbits, which could not have survived if they had been very old.

It seems more likely that the moon was formed after the earth's orbit had become much more nearly circular. Consider for a moment a man in a swing. If he is pulled back for a moment and released, he performs a few oscillations and gradually comes to rest. But if we give him a push every time he is nearest to us, the oscillations get bigger every time. This increase in the extent of a vibration when the force from outside has a period equal to the natural period is known as "resonance." Now, if the liquid earth was distorted so that its equator became an ellipse, it would oscillate backwards and forwards about the circular form till it came to rest, and the period of this motion would be about two hours. But we can show that, if ever the earth and moon formed a single body, this must have rotated in about four hours, and hence the solar tide at any place on it would give the requisite push or pull every two hours. The oscillation would therefore grow, and it is likely that it became so huge that the mass broke into two pieces.

The satellites of Mars offer a difficulty on account of the smallness of their primary. For Mars must have been almost wholly liquid at the start; and if it was broken up by tidal action, it should have produced satellites comparable in mass with itself, whereas they are actually only a few miles in diameter. They may be asteroids that have been attracted out of their original paths and caused to revolve round Mars.

The only other bodies unaccounted for by the theory are comets and meteors. These are almost certainly of more recent origin, and took no part in the birth of the system.

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New Light on Old Authors

II. Vergil among the Prophets

By R. S. Conway, Litt.D., F.B.A.

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It is one of the most interesting facts in the literary, and indeed in the religious, history of Europe that the Roman poet Vergil, who died in 19 B.C., should have been counted for some eighteen centuries an inspired prophet of the Christian Messiah. Nor was the belief merely a popular tradition cherished by those to whom Vergil was only an ancient name, like the belief in his magical powers which survives among the Italian peasantry to this day. It was precisely the most noble and learned students of Vergil's own writings who held the belief most strongly.

The Emperor Constantine recognised Christianity as the religion of the Roman Empire in A.D. 313; and according to his biographer, the Bishop Eusebius, one of the ways in which he justified his action was by appealing to Vergil, the most revered of all the poets of pagan Rome. For, according to Constantine and his religious advisers, Vergil had actually predicted the birth and spiritual reign of Christ Himself, though the poet did not name the Deliverer of the world "for fear of persecution," as Eusebius rather quaintly adds. About a century later St. Augustine, the great Bishop of Hippo in North Africa, who was a devoted admirer and student of Vergil's *Æneid*, still maintained [1] that Vergil himself had embodied in one of his poems a real and older prophecy of Christ; though Augustine did not suppose that Vergil himself fully understood who it was whose coming he thus foretold. The belief remained in Italy all through the Middle Ages. As we all know, Vergil was chosen by the greatest of mediæval poets, Dante, as the spirit in the After-world who might most fitly conduct him through the great exploration of Hell and Purgatory, which is the theme of the first two-thirds of his *Divine Comedy*. Nor is this merely the homage of one great poet to another of kindred spirit. Dante expressly tells us many times that Vergil had the power of converting men to a knowledge of Christian truth. And even though Vergil must relinquish the duty of guiding him at the gates of Paradise, Beatrice, the angel who is to conduct him in this last part of his journey, declares boldly [2] that she "will often speak the praise" of Vergil before her Divine Master. More explicitly still, when Dante meets [3] the poet Statius, whom he supposed to have been a Christian, in Purgatory, Statius is represented as declaring that he owed to Vergil's prophecy his first interest and belief in Christianity. In our own country, no farther back than the year 1709, the poet Pope, in his pastoral poem called "The Messiah," accepts the view of St. Augustine that Vergil had taken over the prediction of an unnamed Deliverer from an earlier prophet called the Sibyl.

Pope was a Roman Catholic and followed the tradition of his Church; but his Protestant critic, Samuel Johnson, that pillar of English common-sense and sound literary judgment, does not in the least demur.[4]

On the other hand, modern commentators on Vergil either pass by the whole matter in silence as a thing beneath their notice, or roundly condemn it as a "ridiculous" or "blasphemous" notion. So we have a responsible scholar of the nineteenth century accusing the poet Dante, and the critic Samuel Johnson, of blasphemy! In these painful circumstances it may interest the readers of DISCOVERY to examine the causes which led the great thinkers and poets whom we have named to interpret Vergil so confidently in this way.

The question is really twofold. First, what was there in Vergil to make his Christian admirers and students think him worthy to be a prophet of the Founder of their own faith; and, secondly, what was the nature of the actual poem in which they thought he had made the prediction?

The first question is altogether too large to be answered here.[5] Suffice it to say that no one has read properly even a single Book of that poet if he has not realised something of the profound and tender-hearted personality which made so many great Christians eager to reckon him as a forerunner of their Master. It is the second question which concerns us here, and to which the study of recent years has made it possible to give at least a somewhat fuller answer than ever before.

In an earlier paper, "The Secret of Philæ," [6] some reference was made to the earliest period of Vergil's poetical work, in which he was closely associated with his fellow-poet Gallus. Like all young poets, they began by imitating their predecessors; and the models to whom it was the fashion to look in Vergil's early days were the later Greek poets who flourished in the third century B.C. at Alexandria, under the patronage of the Græco-Egyptian monarchs who had succeeded to that part of the Empire of Alexander the Great. In that city was the greatest library of the ancient world; and under despotic patrons, originality or breadth of view, or even any great depth of imaginative

[1] *Ep. ad Rom. inchoata expositio*, i, c. 3.

[2] *Inferno*, ii. 73.

[3] *Purgatorio*, xxii. 61.

[4] Johnson, *Lives of the Poets*, edited by M. Arnold, p. 419.

[5] Further details of the reasons which naturally inclined the Christian Church in the early centuries to regard Vergil as prophesying a Messiah, especially his sense of the guilt of mankind, his confident hope of a Heaven-sent Deliverer, and the kind of spirit which he expected the Deliverer to introduce, have been described in the Essay on *The Messianic Idea in Vergil*, to which reference is made at the end of this article.

[6] DISCOVERY, vol. i, p. 4.

feeling, might always lead a poet into danger. But it was always safe to study the work of your predecessors and refine upon their style. So it came about that the poets of the Alexandrian Court specialised in what we may call the graceful or picturesque style of poetry, concerning themselves with comparatively humble or merely sentimental themes. Most of them made it their business to decorate these with a wealth of learning. In particular, they developed the artificial type of poem which we call the Pastoral. Some of the Alexandrian Pastorals, for example several of those by Theocritus, really are what the name implies—pictures of shepherd-life; but most of them were only dialogues of fashionable or literary society prettily veiled by being put into the mouth of shepherds and their comely companions. It was this type of poem to which Vergil first turned when he began to write work of his own. But there is one of the ten Eclogues, as his Pastorals are called, which has somehow transcended the narrowness of the frame in which it is set.

The Fourth Eclogue is full of imitations of older poets, and marked also by much of the pretty fancy associated with a not wholly serious kind of poetry. But it is so original and so complete in itself and so very much in earnest, that it has always been read for its own sake, and even criticised for some of the features which really belong to its framework; that is to say, features which were indispensable if it was to rank in any sense as a Pastoral of the current type, such as the general atmosphere of mythology produced by frequent allusions to old-world stories.

The poem itself tells us when it was written, namely in the year 40 B.C., when Pollio, to whom it is dedicated, was Consul. Pollio was a friend both of Octavian, then just twenty-three years old, and of Vergil himself; and in that year he had rendered great service to Octavian, and indeed to the world, by bringing the turbulent Mark Antony to the agreement with Octavian that is commonly known as the Peace of Brundisium. By this the two practically agreed to divide the Empire between them: Antony was to have the East and Octavian the West. The conspirators who had slain Julius Cæsar had been overcome two years before, and something like the end of the Civil Wars seemed to be in sight for the first time for ten years; the epoch of revolution, in which war of some kind, often civil war, had never ceased, had lasted for nearly a century. The poem celebrates the prospect of this great deliverance, a deliverance which affected not Rome merely, but the whole of civilised humanity. But the poet's hope is linked to one particular event to which he looks forward as a typical part of the new order of things—namely, the birth of some young Prince who is to rule a regenerate world.

The main part of the poem begins by referring to some prophecy attributed to the Greek Sibyl of Cumæ, the legendary figure whom in the *Æneid*, later on, Vergil represented as having introduced Æneas to the Under-world, and whom popular folklore represented as having sold a fraction of her prophecies to King Tarquin for the same sum as she had asked at first for the whole. Vergil's reference was probably not to the official "Sibylline Books," as they were called, which were consulted from time to time by direction of the Senate, but to some more accessible collections of Greek prophecies of the same kind. In them must have been embodied the favourite doctrine of ancient, especially Etruscan, astronomers that at a certain point all the heavenly bodies would be in the position in which they stood at the beginning of the world; and that consequently all human affairs, being, as was supposed, governed by these celestial movements, would repeat themselves over again.

The first of all the ages of Mankind had been, in popular belief, an age of gold under the rule of Saturn. During it gods had walked with men on earth, and the last of the gods to leave the earth because of its increasing wickedness had been the Maiden Justice.

Now it is time to let Vergil speak for himself, at least so far as a rough rendering[1] will allow:

> Lo, the last age of Cumæ's seer has come!
> Again the great millennial æon dawns.
> Once more the hallowed Maid appears, once more
> Kind Saturn reigns, and from high heaven descends
> The firstborn child of promise. Do but thou,
> Pure Goddess, by whose grace on infant eyes
> Daylight first breaks, smile softly on this babe;
> The age of iron in his time shall cease,
> And golden generations fill the world.

From this prayer to Lucina, the Goddess of Childbirth, the poet turns to Pollio, whom he congratulates on the great beginning that is to take place during his Consulship:

> Under thy banner all the stains of ill,
> That shame us yet, shall melt away and break
> The long, long night of universal dread.
> For the child's birthright is the life of gods;
> Heroes and gods together he shall know,
> And rule a world his sire has blessed with peace.
> For thee, fair child, the lavish earth shall spread
> Thy earliest playthings, trailing ivy-wreaths
> And foxgloves red and cups of water-lilies,
> And wild acanthus leaves with sunshine stored.
> The goats shall come uncalled, weighed down with milk,
> Nor lion's roar affright the labouring kine.
> Thy very cradle, blossoming for joy,
> Shall with soft buds caress thy baby face;
> The treacherous snake and deadly herb shall die,
> And Syrian spikenard blow on every bank.

[1] Two other renderings, one in the original metre and one in Biblical prose, both very interesting, are given by Mr. Royds in the book mentioned below.

After this picture of the fairyland which is to surround the infant's cradle, the poem traces the growth of the child to manhood, and the gradual improvement in the world's condition which will keep pace with it; and the prophecy concludes with a kind of magic incantation drawn from more than one philosopher's dream:

> " Run, run, ye spindles! On to this fulfilment
> Speed the world's fortune, draw the living thread."
> So heaven's unshaken ordinance declaring
> The Sister Fates enthroned together sang.
> Come then, dear child of gods, Jove's mighty heir,
> Begin thy high career; the hour is sounding.
> See how it shakes the vaulted firmament,
> Earth and the spreading seas and depth of sky!
> See, in the dawning of a new creation
> The heart of all things living throbs with joy!

Then, after claiming the privilege of celebrating the Prince's later achievements, the poet turns back to the cradle, still waiting for the infant, and prays for a happy birth. The prayer is worded in old-time fashion, bidding the child smile at once upon its mother—accounted the best of good omens—and comparing him to Hercules, most favoured of mortals, who lived to wed Hebe, the Goddess of Perpetual Youth, and to receive the gift of immortality from Jove himself.

> Come, child, and greet thy mother with a smile!
> Ten weary waiting months her love has known.
> Come, little child! Whoso is born in sorrow
> Jove ne'er hath bidden join the immortal banquet,
> Nor deathless Hebe deigned to be his bride.

But now, who was the child whose birth was thus confidently anticipated? That is the puzzle.

In the first place I assume without discussion, as something obvious to every reasonable reader of the lines which have just been rendered, that it was a real child of flesh and blood whose advent the poem was to herald. There have been scholars who have read even the line about the waiting mother in such a way as to interpret the child as a mere allegorical figure, meaning a new world. But after all, as Dr. Warde Fowler observes, one requisite for understanding poetry is a sense of humour; and this seems a little wanting in such interpretations.[1]

Now, it will be easy for the reader himself to observe in the passages that have just been rendered some of the likenesses to Old Testament prophecy, especially that of Isaiah.[2] Nor will he be altogether surprised, though he may well be amused, to find that Constantine and Eusebius interpreted the " Maid " (*Virgo*) of the opening lines as a prediction like that of the birth of Emmanuel.[3] And it is even likely that he will be persuaded if, with recent writers, he studies the matter more fully, that Vergil himself had some direct or indirect acquaintance with the thought and imagery of Isaiah. These are literary questions of interest; but they leave the central point of our curiosity still to be satisfied. Grant that the young poet's vision of a world-wide peace to succeed a century of misgovernment and oppression was dressed in colours like those in which Jewish poets and prophets had depicted theirs. Grant that this great hope kindled within him an enthusiasm so deep and wide that it seemed to wrap the whole world in its light. Grant even that a poet naturally associates a great vision of deliverance with the person of some deliverer. Even if all this be assumed, we still ask, Why was the deliverer to be identified with an infant not yet born, and who was the infant?

On these questions the ancient commentators, who generally tell us most about Vergil, give us some evidence, valuable indeed, but negative. It amounts to no more than that a certain person told somebody else that he, the speaker, was the infant whom Vergil expected to be the world's deliverer. The person in question lived and died and did nothing in particular; but the story shows that the authority that quotes it was himself in the dark, though convinced that the claim of this particular person was absurd.

A further question then arises: What was Vergil's motive in setting his readers such a riddle? Surely even the extracts that have roughly been translated will show that the poet was very much in earnest, not writing a playful sketch of some wholly baseless vision?

Three or four different modern scholars in England, Germany, and America have independently arrived at the same conclusion, guided by the obvious reflection that the child who was to do so much for the world must have been the offspring of someone in whose hands the destiny of the world then rested. As we have seen, Octavian and Antony had just agreed to divide the Roman Empire between them. As between these two names, even in 40 B.C., when Octavian was only at the beginning of his great work, there can be no real hesitation. Could any peace or salvation for humanity be expected from the ruffian[4] Mark Antony, the lover of Cleopatra, even if he had been persuaded to abandon her (for a time) for Octavia's hand? No,

[1] The objection that it was unseemly for a poet to prophesy such an event is a natural one from the point of view of modern English taste; but that the ancient feeling was quite different can be easily shown. See *The Messianic Idea in Vergil*, pp. 30 and 84. There is a poem of Martial in honour of an expected child (of the Emperor Domitian) which was never born at all.

[2] Chapters ix, xi, and xliv.

[3] Isaiah vii. 14.

[4] This view has indeed been maintained, apparently in complete forgetfulness of the facts depicted, e.g., in Cicero's *Philippics* (44–3 B.C.).

if the child was to be a deliverer, the only father that we can attribute to it must be Octavian himself. Further, we know that Octavian's wife, Scribonia, was hoping for a child to be born to her at the end of this very year. Who was this child? It was the Princess Julia, born in January 39 B.C. We know that the sex of the child was a bitter disappointment to Octavian, a disappointment which increased all through his life when no male heir was ever born to him. Is it unreasonable to see in this disappointment the reason for the poet's silence? After all, the poem was published; after all, it concerned the work of the child's father more than the child itself; it concerned the great hopes of the world more than either; and Vergil might well feel in later life, as indeed everyone felt after the wonderful advent of universal peace nine years later, that the hopes had begun to be fulfilled.

[This paper is based on a volume in which the writer had some part, entitled *Vergil's Messianic Eclogue* (John Murray, 1907). Since then the question has been further studied, especially from the point of view of ancient prophecy, by the Rev. T. F. Royds in the volume entitled *Vergil and Isaiah* (Blackwell, Oxford, 1918); and in these two volumes full references will be found to earlier authorities.]

Metal Discoveries of Antiquity and To-day

By Edward Cahen, A.R.C.Sc., F.I.C.

GOLD, as might have been expected from the fact that it occurs native, was the first of all the metals to be discovered by Neolithic man; and even to-day this metal still exerts a greater power for good and evil than any other, though there are now plenty of metals which are more rare and more costly. From our early ancestor's point of view gold possessed the great advantage that it required no smelting, there was no need to find out how to get it from its ores; there the metal was ready for use, glistening in its pristine splendour, and so soft that it could easily be fashioned into ornaments; too soft, it is true, to be of any service for weapons. He therefore had to look round and see if he could not find something a little harder which would serve for this purpose, and it was not long before he came across another native element, copper, from which he fashioned implements of the same shape and design as his stone ones. From copper to bronze is but a little step, and one that may possibly have been taken by accident, as is suggested by Gowland. Its discovery may have been a matter of chance: a little copper ore, with which some tin is nearly always associated, may have got into the stones which served early man for fireplace. The charcoal would smelt the ore, reducing the metals and making an alloy which would be found among the ashes, and seized upon with joy by primitive man as just the thing from which to make fine weapons on account of its superior hardness. Iron was at first a great rarity, and may possibly have been of meteoric origin, and used for ornamental purposes only. Later the Hittites seem to have found out how to smelt it from its ores, and Wells, in his *Outline of History*, records how one of their kings " promises iron as a most precious gift," quoting from a collection of letters found at Tel-el-Amarna. In early Egyptian times silver was also known, but it was esteemed nearly as highly as gold.

From the above very brief sketch it will be seen how very few metals were known in the very early days of recorded events which we call history; since then no fewer than sixty-one metals have been discovered, though even now by far the greater number of them remain as unknown to the great mass of the people as if they had never been found. Yet we shall see how many of the amenities of modern life in great cities are due to the discovery first of all of these metals themselves, and secondly of the use to which they could be put. In this article some account will be given of what are often known as the rarer metals, to distinguish them from those in everyday use such as gold, silver, copper, and iron; the name does not, however, necessarily imply that the metal is rare in the sense that but little of it is known to exist, for many of the rarer metals occur in very considerable quantities—titanium for instance, which is so largely employed in the steel industry, and also for colouring practically all the artificial teeth.

What usually happens is that a new metal is discovered at first in very small quantities, some peculiar properties it may possess mark it out for some particular use, search is made for more of the metal and more is generally found. In this way the supply keeps pace with the demand. At other times large quantities of one of the rarer metals may be associated with very small quantities of another for which a use has been found; a large and accumulating surplus of the other is thus created, and the problem arises what is to be done with this waste-product, a problem which has to be solved by some new discovery.

The gas-mantle industry furnishes us with by far the best example of both these cases, and particularly the latter. It was discovered that the oxide of a rare metal, thorium, which was found in certain rare minerals from Norway, glowed with a very powerful

light when rendered incandescent with heat. Search was therefore made to discover other minerals in which this rare metal occurred in quantities plentiful enough to start an industry. The Germans were not long before they discovered a sand on the sea-shore of Brazil which answered the purpose exactly. This was monazite, which consists chiefly of a phosphate of a rare metal, cerium; but it also contained about 6 per cent. of the thorium, the metal of which they were in need. The story of how the Germans succeeded in getting the monopoly of the monazite of practically the whole world is a very interesting one, but we have not the space to tell it here; suffice to say that the outbreak of war in 1914 put an end to this state of things, and secured for Great Britain the use of her own supplies from Southern India and Ceylon. The thorium was extracted from the sand, and Auer von Welsbach, after numberless experiments, found out how to make the gas-mantles which are so common a feature of every home. These mantles consist of 99 per cent. thorium oxide and only 1 per cent. cerium oxide, these proportions yielding the brightest light. The problem therefore arose how to use up the waste cerium and the other rare elements, such as didymium, associated with it. A use was found for a very small quantity of didymium for printing the trade mark on the mantles, the oxide of this metal showing up pink on the white background of the mantle. But this small quantity had in no way solved the problem, when Welsbach noticed that, if all these metals were reduced together to the metallic state, he obtained a mix metal which when struck against steel emitted bright sparks; in this discovery we have the origin of the countless pyrophoric alloys which can be bought to-day either as cigarette-lighters or as contrivances with which to light the kitchen gas-ring. These mix metals or pyrophoric alloys are now being manufactured in huge quantities at a quite reasonable figure in America and elsewhere.

The rare metals have, however, served in another way to make life brighter for us: of the countless electric bulbs which illumine our dwelling-houses and offices, practically all are now composed of metal filaments (hence their name "metal filament lamps" or "drawn wire lamps") which, when rendered incandescent with the current, glow with a bright light in their little glass globes from which the air has been extracted. In the earliest of these lamps the filament was made of carbon, and the connection with the current was by means of thin platinum wires. These early efforts were very feeble when compared with the metal filament lamps of to-day. The metal now employed in their construction is for the most part tungsten, though this is by no means exclusively the case. This metal, although it is by our definition a rarer metal, occurs in very large quantities throughout the world as the mineral wolfram, which is found among other places in our own Cornish tin-mines, where it was a source of endless trouble to the early miners, who threw it out on the dumps, not knowing what to do with it. Since these early days tungsten has become more valuable than the tin itself, not only on account of its use in the electric bulb industry, but also for the peculiar properties it confers upon steel, when it is alloyed with the latter, and it has given rise to what is tantamount to a revolution in this industry. Although tungsten was by no means the first metal to be used in the steel industry for this purpose, and is certainly not the only metal in use to-day, it is perhaps of greater importance than any other. On tungsten depends the resistance of armour plate to enemy attack, and it is also invaluable in the production of high speed tools, which do not lose their temper even at a red heat. Tungsten has on these two counts been called the key-metal of this war by Colin G. Finck, who in a clever little article has shown that the nation which could command the supplies of tungsten was bound to gain the mastery, as the Neolithic man armed with bronze was certain to overcome his predecessor armed alone with stone, and be overcome in turn by his successor with arms or iron; and so on throughout the ages, every victor in turn gaining the mastery over his opponent by the ascendancy conferred on him by some key-metal. It seems hardly credible, under the circumstances, that when the war broke out we were absolutely dependent on Germany for our supplies of tungsten, though the ores were actually exported from these shores only to be returned to us as metal. This state of things was very soon altered by the erection of a Government tungsten factory at Widnes in Lancashire, and Great Britain was rendered self-supporting in this all-important metal.

Most of the metals used for endowing steel with special properties are prepared in the form of iron alloys; among these may be mentioned ferro-manganese, ferro-tungsten, ferro-chrome, and ferro-vanadium. As a rule they are prepared by one of two methods, the thermit process or the electrical furnace, in both of which high temperatures are reached. The use made of the rare metals is surprising to anyone not conversant with this matter. To take but one example: vanadium is a rare metal, which some thirty years ago was worth £90 per pound and was little more than a chemical curiosity; in ten years the price fell to £3, and to-day a ferro-vanadium containing 30–35 per cent. vanadium can be bought for 30*s.* the pound and considered dear at the price. The reason for this changed state of affairs is the huge demand created by the wonderful vanadium steels,

which are imbued with a perfectly miraculous elasticity.

To supply this demand for vanadium, an entirely new source was discovered in the carnotite beds on the borders of Utah and Colorado. This mineral is little more than an impregnated sandstone; and though it is excavated in enormous quantities primarily for the vanadium it contains, it gives rise to a waste-product more valuable than the vanadium itself. This is uranium, another rare metal, which in its turn yields yet another rarer than itself, the famous radium, which caused such a sensation a few years ago, when Madame Curie succeeded in isolating it from many tons of pitch-blende. It remains to-day the most costly of all the rare metals, though in this respect the metal platinum needs some beating, being worth more than £40 per ounce to-day, whereas a century ago an ounce could be bought for a few shillings. The reason for this enormous rise in its price is due to the actual rarity of the metal and the manifold uses to which it can be put. The family to which this metal belongs is a very select one comprising but six members. Of these metallic aristocrats the best known are palladium and iridium; the latter being familiar to most users of fountain-pens, for it is from this metal that the points of the gold nibs are made, together with another member of the same family, osmium, which is alloyed with it. Palladium has received a good deal of attention during the war as a possible substitute for the prohibited platinum, the stores of which had to be reserved for a multitude of national needs, where it was not possible to use another metal. Palladium has been used with some success in the jeweller's art, though it does not possess the unique properties of the nobler metal. The Platinotype Co. have, however, produced a palladio paper which is in every way the equal of, if not superior to, the well-known platinotype papers.

This search for a substitute for platinum has led to the development of another rare metal, tantalum, which has been used with great success for making dental instruments, being very hard, easily sterilised, and not subject to rust. In tantalum we have a metal of which there is plenty to be had, and for which as yet but little use has been found. We have already seen how the Germans, in their search for a cheap source of thorium, discovered monazite in Brazil. This country is the home of yet another rare metal which has had quite a vogue during the last few years. This is zirconium, which occurs in huge quantities in the mineral brazilite, which is almost pure zirconium oxide, from which it is not difficult to obtain the pure material. This is sold under the proprietary name Zircite. It is now being used in ever-increasing quantities as a refractory substance for the manufacture of crucibles, furnaces, and other articles which are required to withstand the high temperatures which are now so easily attained with modern electrical contrivances. Another rather interesting use to which the oxide of this metal has recently been put, chiefly in America, is as a cheap substitute for the expensive bismuth carbonate used in medicine for making X-ray photographs. Zirconium, moreover, finds many other uses in the steel industry and in the drawn filament electric lamps. Combined with yttrium, yet another rare metal, belonging to the family of the rare earths, it is used in the manufacture of the Nernst lamps, formerly much in evidence in physical laboratories. It also finds a special use in the Bleriot automobile head-lights. Zirconium is typical of a case where, given the material, uses will quickly be found for it should it possess particular properties.

There are two or three rare metals for which as yet no use has been found, either because they possess no very distinctive property, or perhaps because they really only exist in very small quantities: who can say? Time alone will answer this question. Of these germanium, gallium, and indium may be mentioned here; and they are interesting from another point of view as being illustrative of the way in which a new metal is discovered. This may happen in several ways; more often than not the chemist stumbles across a new metal when least expecting it, or he may set out more or less deliberately in search of one the existence of which has been predicted. Gallium and germanium are instances of the latter course; they were both predicted by the Russian chemist Mendeléeff by means of his great discovery the "Periodic Law." It was in 1875 that Lecoq de Boisbaudran discovered gallium in a blende from the Pyrenees, after an extensive spectroscopic examination of many minerals. Germanium came to light ten years later, when Winkler was making an analysis of a new silver mineral and found there was a uniform shortage of 7 per cent. in his analysis, which led him to suspect the presence of some unknown metal.

Indium, on the other hand, is an example of the accidental method. In 1861 Reich and Richter were examining two Freiberg blendes for the rare metal thallium, discovered by Sir William Crookes two years earlier; they failed to detect it by means of the spectroscope, but were rewarded by discerning the lines of an unknown metal which they named indium. Thallium is an example of a very rare element having found a use, owing to a peculiar property possessed by it alone, namely the brilliance and high refractive power it imparts to glass, making it particularly suitable for optical work. A source of supply sufficient for this purpose was found in the flue-dust of those pyrites burners where ore containing thallium was burnt.

It may be said that it is absurd to try and give some idea of the importance of the discovery of the rarer metals in so short an article, when each metal is almost capable of yielding a little romance of itself; but in a magazine for general readers it is hardly the business of a writer to dive too deeply into his subject, but rather to suggest the vastness of the subject with which he is dealing. Of the magnitude of the importance of these rarer metals in our modern life there can be but little doubt, and this is reflected in the enormous number of books which have appeared on the subject in one or other of its branches in practically all languages. The four books mentioned below will give the reader a fuller insight into the various branches of the rarer-metal industry.

Monographs on Inorganic and Physical Chemistry. *The Metals of the Rare Earths*, by J. F. Spencer. (Longmans, Green & Co., 1919, 12*s.* 6*d.*)

Manuals of Chemical Technology. *The Rare Earth Industry*, by Sidney J. Johnstone. (Crosby, Lockwood & Son, 1915, 9*s.*)

The Mineralogy of the Rarer Metals, by Edward Cahen and W. O. Wootton. (Charles Griffin & Co., 1920. Second edition just published, 10*s.* 6*d.*)

Die Darstellung der Seltenen Erden, by C. Richard Bohm. (Leipzig, 2 vols., £2 2*s.* 0*d.*)

Outstanding Economic Problems

By Douglas Knoop, M.A.

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So far as this country is concerned, there appears to most people to be one outstanding economic problem at the present time—the problem of high prices. Really the problem is something much wider: it is like a jewel with many facets. The particular facet which we most commonly observe reveals high prices to us. Another facet, however, shows us scarcity. This, for example, is the way the housing problem presents itself to us; it is not so much a question of high rents, but of shortage of housing accommodation which impresses itself upon us. The aspect of scarcity is also felt, though to a less marked degree, in connection with butter and sugar, and with motor-cars and motor-cycles. Scarcity and high prices are always associated together; the competition of would-be buyers seeking to obtain the limited supplies drives up the prices. But with the principal exception of housing, public attention here is much more concentrated on the high prices than on the scarcity aspect of the problem. This is perhaps partly because effects are more easily seen than causes, but partly because the high prices appear to be out of all proportion to the scarcity. This leads us to examine some other facets of our jewel. One facet reveals that a special reason for high prices can be found in the existence of too much paper money, or currency inflation, as it is commonly called. Another facet shows us the closely related phenomenon of the Government relying too largely on advances from banks, and other forms of temporary borrowing, instead of financing itself by means of tax revenue and long-dated loans subscribed for out of the savings of the citizens. Excessive temporary loans, like excessive issues of paper currency, tend to raise prices. Still another facet reminds us of the fact that, when we try to buy foreign currency in order to pay for goods purchased abroad, our pound in many cases no longer has its old power in exchange. This is particularly detrimental to us in the case of purchases made in the United States—our chief source of supply—where our (paper) pound is worth only about $3\frac{3}{4}$ dollars instead of the normal $4\frac{13}{15}$ dollars. Canada and India are two other important sources of supply where our pound no longer purchases as many dollars or rupees as was the case before the war. Let us take an example to show how the unfavourable foreign exchanges help to raise prices here. Before the war, an American product selling for 5 dollars would have cost us approximately 20*s.* 6*d.* Suppose the price in the United States has now doubled. Had the exchange remained normal, we should have been able to purchase the article for 41*s.*—but actually we shall have to pay something like 55*s.* 6*d.*

There are still two more facets of the jewel to which attention may be drawn. One shows us transport difficulties: scarcity of shipping, accentuated by congestion at the ports, which prevents us from getting the best use out of such shipping as is available; and congestion on the railways, which, like scarcity of shipping, prevents goods from being delivered when and where they are wanted. Thus scarcity of goods and high prices are aggravated. The other facet discloses the artificial barriers to trade—such as embargoes and licences. These obstacles to trade have similar effects to defective transport facilities—that is, they increase scarcity and tend to raise prices.

Readers may urge that I have omitted to contemplate one important facet of the jewel, which would portray "profiteering." I have done so deliberately, because "profiteering" is *not* a cause of high prices; it is an effect of high prices, which are caused primarily by scarcity and excessive spending, and in a lesser degree by currency inflation, by unsound loan and taxation policy on the part of the

Government, by unfavourable foreign exchanges (themselves largely due to inflation), by transport difficulties and by artificial trade barriers. If these troubles can be overcome, high prices and the consequent tendency for profiteering will be eliminated simultaneously.

Before discussing, however, the possible cures for our present economic troubles, I want to widen the survey to embrace a brief review of Continental conditions. I do so, partly because many of the countries on the Continent of Europe are faced with the same economic problems as ourselves, but in a much more extreme form, and partly because we are essentially an industrial and commercial country, dependent for many of the comforts and necessaries of life upon our foreign trade. Consequently, if the bulk of our customers and of our sources of supply on the Continent of Europe are at present suffering from more or less acute economic disorganisation, it cannot but have a prejudicial effect on our own welfare.

Mr. J. M. Keynes, in his recent book, *The Economic Consequences of the Peace*,[1] has given us a vivid picture of economic conditions and prospects in some of the principal countries of Continental Europe. As the title of the book suggests, he emphasises the economic problems resulting from the terms of the peace, rather than the problems which may be attributed directly to the war, though it is not always easy to distinguish the two sets of problems. If the facet of the jewel which strikes us most forcibly in this country is that which shows high prices, the facet revealing scarcity attracts considerably more attention in France, Italy, and Belgium, whereas in Germany and Austria it is the dominant consideration. Prices are in many cases appallingly high in these countries, but scarcity, to the point almost of the complete absence of many of the comforts and even necessaries of life, is the aspect of the problem which impresses itself most forcibly upon the inhabitants. More or less extreme scarcity, combined with a flood of paper money, compared with which our over-issues of currency notes appear quite modest, would alone easily account for the tremendously high prices which prevail; but the other contributory causes mentioned above in connection with our own problem of high prices are also present on the Continent in aggravated forms—unsound public finance, unfavourable foreign exchanges, transport difficulties and artificial trade barriers.

The existence of all these phenomena on the Continent can be regarded to a considerable extent as direct or indirect results of the war, even as they are in this country.

The devastation of large areas and the destruction of mines, works, and farms, together with the lack of manures and artificial feeding-stuffs, accounts for some of the special scarcity on the Continent. Further, the disorganisation and congestion on the Continental railways, together with the wearing out of their rolling stock and running tracks, is much more serious than with us. But undoubtedly part of the acuteness of the economic ills from which so much of the Continent is suffering may be attributed to certain terms contained in the Peace Treaty. For a detailed examination of the question I must refer the reader to Mr. Keynes's book. Here I can only touch on the matter quite briefly. The dominant motives underlying the peace negotiations, if we accept Mr. Keynes's analysis of the Versailles Conference, were political and territorial rather than economic. Some readers may, and others may not, accept this view, but in any case there seems little or no doubt that certain of the provisions of the Treaty, whether they were inserted for economic or for other reasons, are almost bound to have a prejudicial effect on the economic recovery of Europe after its five years of war and destruction. Attention may be drawn to just a few points. Under the heading of reparation, an immense indemnity of uncertain amount is to be paid by Germany. In the first place, the uncertainty of the amount Germany is called upon to pay cannot fail to have a bad effect upon the productiveness of German industry, as the Germans, realising that any surplus produced is to be handed over to the Reparation Commission, are not likely to produce any surplus. In the second place, the possibility of receiving large sums by way of reparation encourages the Continental Finance Ministers to continue the unsound financial policy adopted during the war, of placing far too much reliance on loans and on over-issues of paper money. In the third place, if the great indemnity were to be paid, it could only be achieved by Germany developing an enormous export trade, either with the Entente Powers or with neutral countries, which would hardly be in the interests of our export industries.

As a matter of fact, this last contingency seems hardly likely to arise, because the same Treaty, which contains terms about a great indemnity, contains other terms which make the payment of such an indemnity almost impossible. It is hardly feasible both to kill the goose which lays the golden eggs and to receive a regular supply of the golden eggs. Yet that is apparently what the Treaty attempts to do, because in addition to imposing the indemnity, it aims at very seriously restricting, if not actually destroying, the economic life of Germany. The loss of an important part of its coal and iron ore deposits on the one hand, and of the bulk of its mercantile

[1] Published by Macmillan & Co., 8*s*. 6*d*. net.

marine and overseas investments on the other, must severely handicap a country which before the war was primarily an industrial and commercial country. Whilst a great expansion of German industrial and commercial activity might prejudice certain of our industries, the economic ruin of Germany would probably prove equally or even more prejudicial to our economic interests. Commerce is to the mutual advantage of the different parties that participate in it; just as a big business firm does not wish to see its customers go bankrupt and its sources of supply dry up, so this country, which is above all things a trading country, stands to gain much more by developing its Continental trade than by restricting it.

Where are we to find the remedies for the economic ills from which we are suffering? Undoubtedly, by seeking to remove the causes which are leading to the high prices. Some system of Government control may possibly check high prices and profiteering; but it will certainly tend to aggravate scarcity, and thus accentuate the most fundamental cause of all our present economic woes. A much better answer, or series of answers, to the question is supplied by the Supreme Council of the Peace Conference, in their recent declaration on the economic conditions of the world (see daily papers, March 10). It is noteworthy that the recommendations contained in this memorandum are much more likely to rehabilitate Europe than any provisions contained in the Treaty. Scarcity, in conjunction with keen competition on the part of Governments and the general public to secure the limited supplies available, is the prime cause of the high prices. The Supreme Council consequently recommend reduction in expenditure by Governments and individuals on the one hand, and efforts to increase production on the other. With these recommendations every economist will be in agreement. To facilitate the increase in production, the Supreme Council recommend the granting of commercial credits to impoverished countries to enable them to provision themselves with raw materials, and they make a somewhat similar recommendation with regard to help to Germany. One other point on which the Council lay stress is the necessity for an early deflation of credit and currency: payment of current expenses out of current revenue, the cessation of borrowing, the substitution of long-dated for short-dated and temporary loans, and the immediate limitation and gradual curtailment of the note circulation. These steps, if carried out, besides tending directly to lower prices, should render the foreign exchanges less unfavourable, and ultimately restore them to the normal level.

The Supreme Council appear to make no special reference to the prevailing disorganisation of transport facilities on the Continent, or to the artificial barriers to trade which various new countries, set up under the Treaty, appear to be erecting against each other. Efforts should undoubtedly also be made to overcome these contributory causes of high prices.

Whilst I have tried in this article briefly to examine the problem of high prices primarily from the point of view of this country, I trust that I have said sufficient to show that for this purpose the United Kingdom cannot be isolated from the Continent of Europe. Our economic recovery from the destruction and loss caused by the war is undoubtedly dependent to a considerable degree upon the economic recovery of the Continental participants in the war. Anything which either helps or impedes that recovery is therefore of immediate interest to us. Many of the troubles are either direct or indirect consequences of the war; but some, it seems hardly possible to doubt, must be attributed to the terms of the Peace Treaty. Mr. Keynes's book provides a most valuable examination of this side of the problem. I strongly advise the reader to secure a copy and to study it for himself. I would give him only one word of warning—had the Treaty been as different as it could be from that actually signed at Versailles, we should nevertheless to-day be suffering from most, if not all, of our present economic ills; no Treaty, however wisely drawn up, could wipe out in a day, or even in a year or two, the effects of five years' almost world-wide destruction. Recovery must necessarily be slow. The real economic question, so far as the Treaty is concerned, is whether its terms are likely to prejudice or to facilitate the economic recovery of Europe. Mr. Keynes has no hesitation in giving his answer to this question, and I imagine that many of those who read the book will accept his conclusions.

Will Tuberculosis Die Out?

By Louis Cobbett, M.D., F.R.C.S.

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For some centuries leprosy has been dying out in Europe, and is now all but extinct. It lingers only in a few outlying, backward places, such as parts of Norway, Russia, Spain, Portugal, Greece, and Turkey. From the more progressive countries it has entirely disappeared. From Great Britain it had practically gone at the time of the Reformation; the last indigenous case occurred, in the Shetlands, in 1798; and

now only an occasional instance is seen, in London or Liverpool, imported from abroad.

Yet in ancient times the disease was very prevalent. It flourished in the thirteenth century, when there were said to be over 2,000 lazarettos in France. Robert Bruce died of it in 1329. Experts tell us that there is no doubt that the disease called leprosy in the Middle Ages was the same as that known by this name at the present time—though, doubtless, other conditions were often confused with it. There can therefore be no doubt that a dreadful disease, which was once quite common here, has, in these islands at least, become extinct. Will tuberculosis go the same way—tuberculosis, which causes more deaths in temperate climes than any other infectious disease, and whose economic importance is enormously enhanced by the fact that it carries off so many of its victims in the prime of life? Will tuberculosis become extinct like leprosy?

This is no idle speculation; for already the death-rate from tuberculosis has declined so remarkably that it is now considerably less than half what it was in the middle of the last century.

But, it may be asked, can we really be sure of this? Are the figures to be trusted to the extent that we can safely compare our present returns with those of sixty or seventy years ago? Are the death-certificates of those days, on which of course the official figures are based, sufficiently accurate? May not deaths due to bronchitis or pneumonia have got put down to phthisis, consumption, or pulmonary tuberculosis (they are all one)? And do not such errors depend on ignorance, prejudice, or even custom? May it not also fairly be claimed that medical knowledge has made immense strides since those days, and that prejudice and custom, though no doubt still with us, do not take the same forms that they did? Are the statistics of to-day, then, really comparable with those of a bygone era? To put the objection concisely, it might perhaps be urged that in those more ignorant times of which we are speaking there was a tendency to put down every complaint of the lungs, and indeed of the bowels too, to consumption; and that the decline in the recorded death-rate from that cause has been due merely to continuous improvement in diagnosis. If this is so, the changes which we claim to be evidence of the dying out of tuberculosis are only changes of name. The deaths occur just the same, but are assigned to another cause.

This is a serious difficulty, and one not lightly to be dismissed; but it is too technical to be discussed here, and it must suffice to say that it has received careful consideration from a number of good authorities, and that there is substantial agreement in the conclusion that, while increase of medical knowledge and changes of nomenclature and custom have, doubtless, greatly influenced the figures, yet the errors have to some considerable extent cancelled one another (e.g. when cases of bronchitis were attributed falsely to consumption, cases of consumption also were falsely attributed to bronchitis), and that, on the whole, and especially for such large changes as we are now considering, the figures are to be depended on.

Let us, then, accept the figures as substantially accurate, and pass on to consider what they tell us. Prior to the middle of last century the records, such as they are, are very imperfect. It was not until 1871 that it became compulsory for medical practitioners to give certificates of the cause of death of every patient dying under their care. Before this the majority of deaths were certified, but as late as 1871, 8 per cent. of the total deaths lacked medical certificates. In 1904 the deficit had fallen to 1·4 per cent.

We will begin, then, with 1865, about which time the deaths attributed annually to tuberculosis began to show a decided decline. In that year these deaths numbered over 69,000. In 1913, the lowest year on record, they numbered 49,476. There had therefore taken place, in the space of about fifty years, a decline of 20,000 deaths from tuberculosis per annum, or 29 per cent. of the total in 1865.

In the meantime the population had increased by nearly 70 per cent., and the *death-rate* (or ratio of deaths to population) from tuberculosis had fallen from 3,300 per million to 1,340 per million, a decline of nearly 60 per cent.

A decline of this magnitude is an immense achievement, even if we have to take off something for the reasons which we have been discussing. If we can accomplish as much in the next half century as has been accomplished in the last one, tuberculosis will not only have been ousted from its supreme position as the most fatal of all diseases of civilised lands, but will have sunk to the level of those of secondary importance. Nay, more: let the curve which the declining mortality has followed in the past be prolonged, and it will cut the base-line before the end of the century, and tuberculosis will have become extinct. But stop a moment. Is this really so? What sort of a curve is it? It appears to be a straight line; but is it really so? Let us examine it more closely.

In the chart published by the Registrar-General, giving the annual mortality from tuberculosis since 1850, various irregularities occur from year to year. These are due to such causes as unfavourable seasons, epidemics of influenza, scarcity of food, etc., which bring about the deaths of tuberculous persons earlier than they would otherwise occur, and so cause them to fall into one year rather than into the next, to which, under perfectly uniform conditions, they would

naturally belong. Since these irregularities in no way concern us now, and are indeed disturbing to our present purpose, I have calculated the mean annual mortality from tuberculosis for successive periods of five years, and, having labelled each with the central year of the group, set them in order in the form of the chart which follows, where each column is proportional to one of these quinquennial means.

Even when this has been done, irregularities have not been entirely climinated, but they have been so substantially reduced that it is comparatively easy to see the general trend of the curve. That curve appears, at first sight, to be a straight line. which, if prolonged, would reach the base somewhere about 1950. A decline following a straight line means, of course, an accelerating rate of dimunition; for it implies a fall of the same absolute amount each year, and this constant decrement must bear an increasing ratio to the declining totals. A constant rate of decline, on the other hand, follows a curve with a convexity downwards, a curve which is always flattening out, always approximately to the horizontal, and never reaches the base-line at all. For if you halve an apple, take away one part, and halve the remainder, and continue this process, there will always be something left. Of which sort is our curve?

The fact is that the rate of the decline of the death-rate from tuberculosis up to 1914 was not a constant but an accelerating rate. Nevertheless the acceleration was not such as to produce quite a straight line. The curve does indeed show a tendency, though a small one, to flatten out; and the complete extinction of tuberculosis may, therefore, be farther off than the chart at first sight seems to indicate. But it must be remembered that tuberculosis would be much easier to deal with were there not so much of it, and that its last remnants should be easily stamped out by segregation. We may look forward, therefore, to the problem becoming progressively more manageable as time goes on. After all, then, we need not worry ourselves much as to the exact shape of the curve: the main point is that the extinction of the disease is within sight.

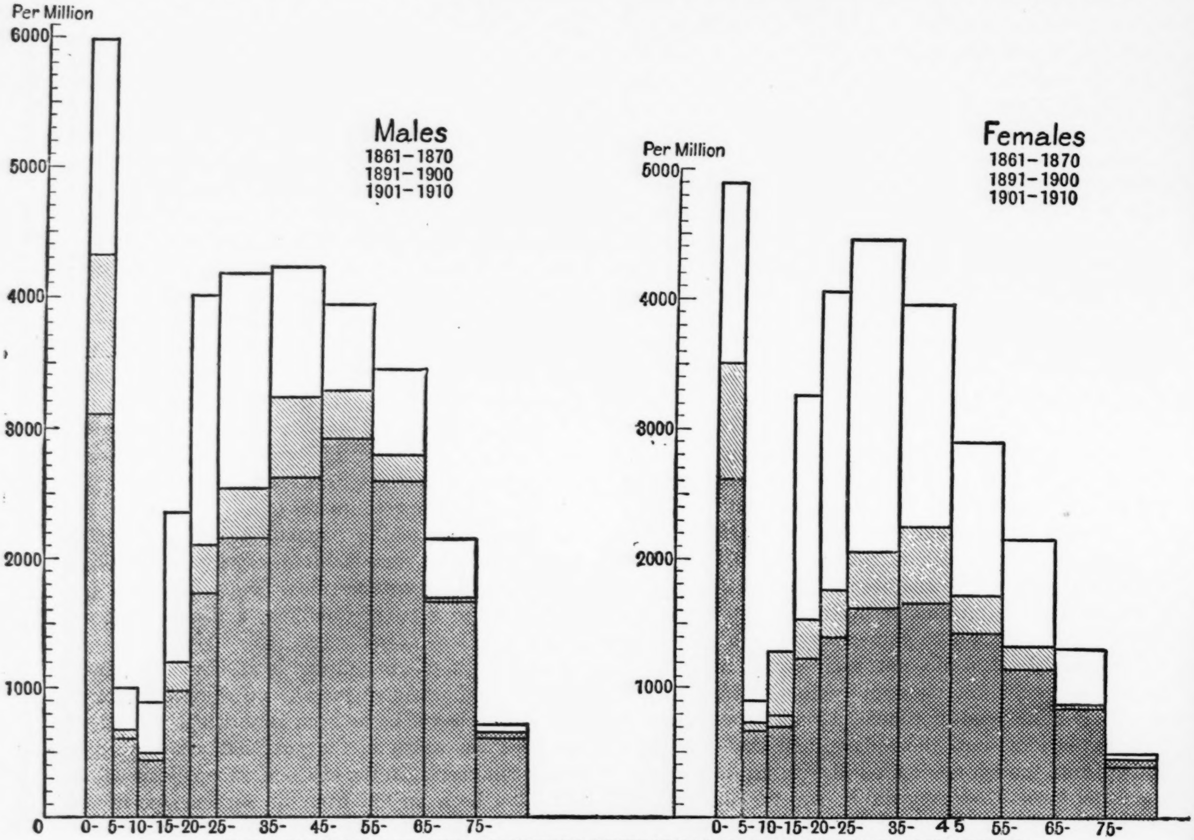

FIG. 1.—THE MEAN ANNUAL DEATH-RATE FROM TUBERCULOSIS IN ENGLAND AND WALES IN SUCCESSIVE (OVERLAPPING) "PERIODS" OF FIVE YEARS.

ERRATUM

Pages 148, 149: The two diagrams should be transposed. Fig. 2 should be Fig. 1, and Fig. 1 should be Fig 2.

Though the promised land may be obscured by mists which diminish visibility and make it difficult to estimate its distance, yet we command a Pisgah height from which the eye—aided no doubt a little by the telescope of imagination—can see the curve of the mortality from tuberculosis steadily approaching its base-line, and, somewhere away near the horizon, we don't quite know how far off, but at least within the range of assisted vision, actually joining its base-line and extinguishing itself in it. When we arrive there tuberculosis will have gone the way of leprosy and have become extinct.

But the causes which have brought about this fall, will they continue to act? May it not be that they have already nearly exhausted their influence? What were those causes? Are they of a nature likely to be permanent? Moreover, may not other causes, possibly, come into action which will reverse the process?

Such a cause was the war. In the year 1913 there were 49,476 deaths from tuberculosis; in 1918, the latest year for which I have the figures, there were 58,073, an increase of 8,597 deaths from tuberculosis of all kinds. (But as a matter of fact the increase was entirely an increase of pulmonary tuberculosis, deaths from other kinds of tuberculosis having actually decreased.) For so bad a year we must go back to 1904, so that the war may be said to have set us back fourteen years, and probably we do not know the worst yet.

The war has exerted its influence on tuberculosis, both in the army and in the civil population. Many persons thought that the open-air life of the soldier would prove beneficial to those in the early and unrecognised stages of consumption. But it was not so. Above all things the consumptive needs is to be taken care of and protected from hardship, even in the earliest stages of the disease. Though plenty of fresh air is, no doubt, a good thing, it will not make up for exposure and fatigue, which are the very worst things. Many a case of infection with tubercle bacilli which, but for the war, might have done well was converted, by active service conditions, from a retrogressive into a progressive tuberculosis. Many a case of quiescent lung trouble broke down under the strain and ended fatally in consumption.

But the civil population suffered also, and more than the army, from this cause, because the great majority of early consumptives were left at home. Let us see how the various constituent elements of the home population were affected.

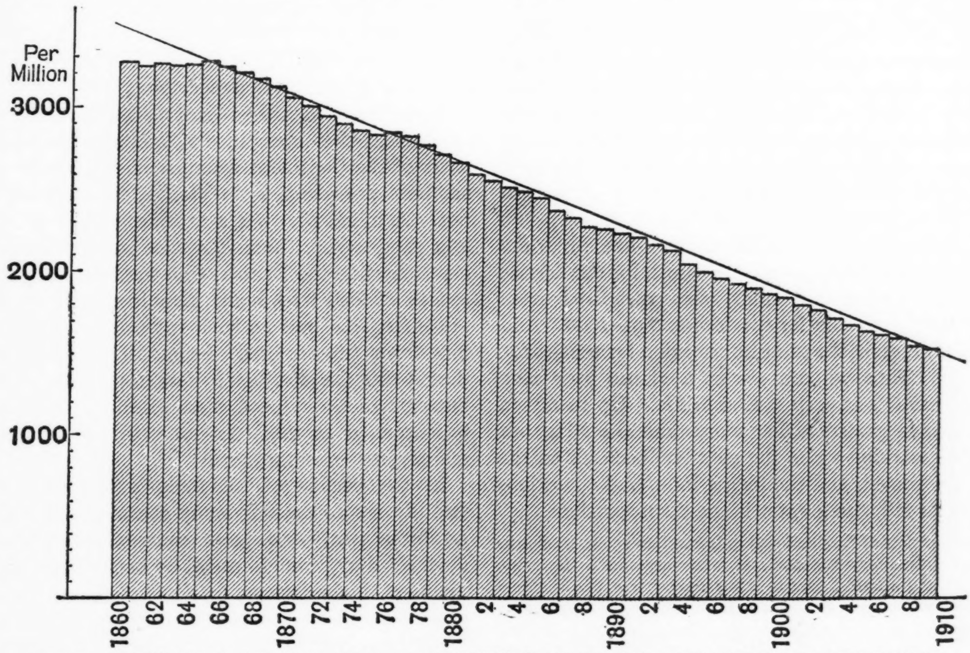

FIG. 2.—ILLUSTRATING THE FALL IN THE MORTALITY FROM TUBERCULOSIS AMONG MEN AND WOMEN.

While deaths from tuberculosis increased among both sexes, it was the women who were more particularly affected, and especially the women at the most active periods of life. Why was this? The answer is easy. The key is given by the fact that during the years before the war, when tuberculosis was slowly dying out, it

was the women who were gaining all the time far more than the men. Once, more women died of tuberculosis than men. They do so still in backward Ireland. But in England the preponderance of deaths was transferred from women to men in 1868; in America the change took place about ten years later, and in Scotland later still. This rate of change corresponded with the rise of the industries in the respective countries. Many trades, from the nature of the dust they produce, or from other causes, are injurious to the lungs, and predispose to tuberculosis. This is notably the case with tin-mining, tool-grinding, and pottery-making, and there are many others; but it is a curious thing that nearly all those trades which predispose to tuberculosis are followed by men, and not by women. This fact it is which has caused the tuberculosis mortality to fall so much more profoundly among women than among men. It may be said that *tuberculosis has declined in spite of the adverse influence of industrialism,*[1] but the decline has been from this cause retarded chiefly among men, especially at the ages between 35 and 65; and between 45 and 55 the decline among men has been little more than half as great as it was among women at the same ages.

Fig. 2 will show how the fall in the mortality from tuberculosis has affected the two sexes at different ages. The figures along the base-line represent ages, the whole period of life being divided into eleven periods, five of them, in the earlier part of life, of five years each, and the rest of ten years each. There is a column for each age, and the two sexes are shown separately. Each column is divided into three parts. The upper limit, measured from the base-line, gives the mean annual mortality from tuberculosis for the decade 1861–1870. The second limit, also measured from the base-line, gives that for the decade 1891–1900. And the third limit gives the same information for the decade 1901–1910. Thus we can see at a glance how each sex has benefited at each period of life. Up to fifteen the boys have gained rather more than the girls, but during the working years the gain has been all on the side of the women, and the longer industrial conditions have had to tell, the greater is the disproportion.

[1] In rural districts of England and in Ireland, in 1908, the death-rate from pulmonary tuberculosis was very much the same among men and women. But in industrial centres, like Sheffield and Birmingham, the death-rate from this cause during the active working years of life, and especially of its later half when industrial conditions have had time to tell, is twice or nearly three times as high among the men as among the women.

The ratio of the amount of decline among females to that of males during the whole period under consideration is given by the figures below.

It is only necessary to recognise the adverse conditions which, so far as tuberculosis is concerned, industrial life has in the past exerted on the males to see why war conditions have had so great an effect upon the mortality from tuberculosis among women. They went in large numbers into factories for the purpose of making munitions. They did work which only men had done before, and they began to be subjected to the adverse conditions which hitherto had affected the men alone.

The infants suffered least, or rather they did not suffer at all, but the decline in the death-rate from tuberculosis from birth to the fifth year of age, which had been progressing rapidly, especially since the beginning of the present century, continued as though no war had been going on. The rate increased a little among the younger children over five years of age, and it increased rather more among the older children. Why was this? It was, probably, because of the shortage of food, especially of fatty food, and especially of milk. Whatever happened the baby was to receive its proper quantity. If there was not enough to go round, the children might go short, and it was the older children, rather than the younger ones, who had to suffer.

The experience of the recent past, indeed, has strongly emphasised the importance of food in tuberculosis. In parts of the Continent where semi-starvation or worse has been prevalent, as in Vienna, tuberculosis has run riot. A friend who was a prisoner of war in Germany, in a camp where there were also many Russians, tells me that while the British, who were well supplied with parcels of food from home, remained well, the Russian prisoners, who had no such resources, were dying like flies from tuberculosis. From all accounts we hear that it was the shortage of fats, especially of milk and butter, which produced these results. And we cannot be surprised at this. Is not cod-liver oil the staple remedy for consumption?

In the decline of tuberculosis which went on so steadily before the war many causes are thought—and no doubt justly—to have contributed. Decrease of overcrowding (brought about by better housing), politer manners, higher wages (conducing to greater comfort generally, especially more plentiful and more nourishing food), the cult of the open window, all these have played their part. For tuberculosis, though indeed it

RATIO OF FEMALE TO MALE DECLINE IN THE DEATH-RATE FROM TUBERCULOSIS BETWEEN THE DECADES 1861–1870 AND 1901–1910, THE DECLINE AMONG MALES AT EACH AGE BEING TAKEN AS 100.

Ages.	All ages.	0–5,	5–10,	10–15,	15–20,	20–25,	25–35,	35–45,	45–55,	55–65,	65–75
Ratios	**128,**	**96,**	**68,**	**94,**	**107,**	**114,**	**129,**	**150,**	**196,**	**184,**	**154**

spares no class, falls heaviest on the poor. Poverty, overcrowding, dirty habits, bad ventilation, poor feeding, are the causes of tuberculosis, and the causes of its decline have been well summed up in the phrase, *The amelioration of social conditions.*

But when all these causes of tuberculosis are taken into consideration, two stand out predominantly among the rest—overcrowding and bad feeding. Overcrowding favours the passage of infection from the sick to the healthy, and bad feeding predisposes the latter to the disease. Thus one cause sows the seed and the other prepares the soil; for without preparation the seed of tuberculosis will not flourish.

The causes of the decline of tuberculosis are by no means nearing exhaustion. Not yet does everybody receive as much food as he can do with, and that of the most suitable kind and quality. How our fathers lived it is difficult to understand. Underfeeding must have been the rule, something like famine common. Progress in agriculture and importation of foreign food has done much, and, compared with what was the case a century ago, our poorer classes live like fighting cocks.[1] But we have not yet seen the end of the movement, and we must not think that there is no need for further improvement in the feeding of the people. Much also remains to be done in the matter of education, and in health-education, before overcrowding will be extirpated, and people have learnt not to facilitate the spread of infection from the sick to the healthy. We are therefore not at the end of our resources. Far from it. Much remains to be done on the lines which, there is good reason to think, have brought down the tuberculosis mortality so wonderfully in the past.

Doubtless the present high prices and lack of houses are keeping up the adverse conditions begun by the war. But these will yield to time; and once more we may expect to see the tuberculosis mortality continuing its steady decline until the disease has sunk to the status of an uncommon infection. And this, too, will be only a stage before its complete eradication. Tuberculosis will go the way of leprosy and become extinct.

NOTE.—Further information on this subject may be obtained from a book by the present writer entitled *The Causes of Tuberculosis.* (Cambridge University Press, 23*s.* net.)

[1] Gilbert White, in a letter to the Hon. Daines Barrington dated 1778, and published in his *Natural History of Selborne,* gives an interesting account of the progressive improvement of the food of the people, which was evident even at that date, and attributes the disappearance of leprosy very largely to this cause.

Textbook of Inorganic Chemistry. Vol. ix, part i. By J. NEWTON FRIEND, D.Sc. (Griffin, 18*s.*)

The Class-Room Republic. By F. A. CRADDOCK. (Black, 2*s.* 6*d.* net.)

Place-Name Study

By Allen Mawer, M.A.

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AMONG recent developments in English linguistic studies, none is more marked or likely to be more fertile in results than that which has taken place in the study of our place-names and, incidentally, of our personal names.

Interest in the meaning of the names of those places with which we are in daily contact is innate in most of us, and, from the earliest times, attempts have been made to interpret them. Sometimes, as in the modern *Bear Park* (co. Durham) for earlier *Berper* (from O.Fr. *beaurepeir*, "beautiful retreat"), we have simply a case of folk-etymology; but in others more alluring methods of interpretation, by means of some picturesque legend, have been adopted. Thus *Dukesfield* (near Hexham) is commonly explained as the field where the Duke of Somerset was captured and executed after the Battle of Hexham in 1464, regardless of the fact that it is found as *Dukesfeld* in 1296; or *Brancepeth*, commonly written and pronounced *Brawnspeth* in the eighteenth century, is made the final stage of a great hunting of a *brawn* or boar, which began at Ferryhill and ended here, though *Brawnspeth* is the perfectly natural development of a twelfth-century *Brandes-peth*, i.e. Brand's path.

It was not until the beginning of the present century that deliverance from these fascinating but unscientific methods of explanation first came. In 1901 the late Professor Skeat wrote a little volume on the *Place-Names of Cambridgeshire*. In it he laid down for the first time, in England at least, what must be the guiding principles of all place-names study, viz. (1) that place-names can only be interpreted in the light of earlier forms; (2) that the interpretation of these forms can only be undertaken satisfactorily by the skilled philologist. Thus *Cambridge* itself is not the "bridge over the Cam," but the "bridge over the Granta." The earliest form is *Grante-brycg*, and this by a succession of well-established sound-changes became *Cantebrugge*, *Canbrigge*, *Cambrugge*, *Caumbrege*, *Cambryge*, until at last people began to say to themselves, "Surely there must be some mistake, *Cambridge* must be named from the river on which it stands; the proper name of the river is clearly not *Granta* at all, but *Cam*"; and so in the end *Grantbridge* became *Cambridge* and *Granta* became *Cam*.

The next great advance came when in 1911 Professor Wyld, working in collaboration with Dr. Hirst, brought out his *Place-Names of Lancashire*. He developed the principles laid down by Skeat, and put even more stress on the necessity of the work of the trained phonologist in interpreting the forms in use from the earliest found in MS. records down to the latest heard locally from the lips of present-day Lancashire people. A good example of his methods of work is seen in his treatment of the name *Liverpool*. Here we have the crux of four well-established forms of the name existing side by side in the sixteenth century, viz. *Liverpool*, *Leverpool*, *Litherpole*, *Lerpoole*. Wyld shows how the first two and the last are perfectly regular phonological developments of an early *Lēofhere's pool*, while the third is only another example of false analogy. No reasonable interpretation could be offered of *Liver-pool*; there is a *Lither-land* a few miles down the river, which in the sixteenth century would readily be interpreted as "foul-land," so why not imagine that *Liver-pool* was a mere blunder for the *lither* or dirty pool, and correct it accordingly?

Almost at the same time that Wyld's work appeared, the late Dr. Moorman brought out his study of the *Place-Names of the West Riding*. Here new ground is opened up in the attempt made in its "Historical Introduction" to deal with some of the larger problems which lie at the back of our place-nomenclature, problems of race, settlement, civilisation, etc. Any such attempt was probably premature, for these problems can only be dealt with satisfactorily when the evidence for the whole of England has been collected and sifted, but it is important that this side of the question should be kept alive. Another suggestive book on these lines is the essay on the *Place-Names of Berkshire* by Professor Stenton, of Reading. It is well worthy of study as a moderate and well-balanced statement of all that the development of place-name study may mean for the student of history. Hengest may or may not have been a real person, but it is well to note how popular this hero must have been when his name, otherwise unknown in historical times, is found, as Stenton points out, as the first element in Hinksey in Berkshire, Hinxston in Cambridgeshire, Endscot in Devon, Hinxworth in Hertfordshire, Hinksford in Staffordshire; and, we might add, Hingeston Down in Cornwall, and Hinxhill in Kent.

Of the other writers who have dealt with the place-names of any particular county, and have at the same time suggested new lines of investigation, we may mention three. Baddeley, in his *Place-Names of Gloucestershire*, includes a good many notes of interest on Middle English names which have now disappeared from the map. Ekblom, in his *Place-Names of Wiltshire*, is one of the few scholars who make any serious attempt to deal with the many problems that arise from a study of Anglo-Saxon Charters. Goodall, in his *Place-Names of South-West Yorkshire*, makes a bold attempt to deal exhaustively with the names found in a certain limited area.

Finally, in any attempt to characterise the various types of place-name work that have been undertaken, mention should be made of the fact that Professor Wyld and his pupils (in their books on the *Place-Names of Oxfordshire, Derbyshire, Nottinghamshire,* and *Sussex*) write definitely and exclusively from a philological point of view. They leave for later settlement by the historian and the topographer the question as to whether their explanations are in accord with the facts of history or topography. Whether that is wise we need not discuss here. All that we need say is that, in the light of this wider knowledge, there is no doubt that many of the explanations now given will have eventually to be abandoned.

Side by side with place-name study there has developed, as its necessary concomitant, study of our personal names. A large proportion of our place-names are, so far as their main theme is concerned, derived from the names of their sometime settlers, owners, or occupiers, and these can only be properly identified when we know more of the history of our personal names. The late Dr. Searle compiled an *Onomasticon* containing a list of all Old English names found before 1100, but it is essentially unscientific, and included many names that are not English at all, and a good many ghost-names. Much has been done to remedy this by Scandinavian scholars. The late Professor Björkman, of Uppsala, did brilliant work on Old and Middle English names of Scandinavian origin in his *Nordische Personennamen in England* and *Zur Englischen Namenkunde.* Two of his pupils have dealt very thoroughly with other themes—Dr. Forssner with *Continental-Germanic Personal Names in England,* and Dr. Redin with *Uncompounded Personal Names in Old English.*

One other subsidiary study must be mentioned. A large proportion of the forms on which we are dependent for our work are preserved in documents—*Charter Rolls, Patent Rolls,* and the like—written by official scribes who were much better skilled in Anglo-French or in Latin than in English. The student of these documents is greatly hampered by the strange vagaries in the spelling, and even in the pronunciation, of place-names which have resulted from this. Scandinavia has again come to the rescue in the person of Dr. R. E. Zachrisson, whose book on *Anglo-Norman Influence on English Place-Names* must be the vade-mecum of anyone who attempts to take up these studies.

Here, then, we have a record of experiment on various different lines, of much essential preliminary spadework in allied fields of study, and, at least on the face of things, a goodly record of definite accomplishment. Let us consider briefly what remains to be done if work on English place-names is to be carried to a successful conclusion.

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In the first place it is important to realise that, though work has already been done on some twenty counties and on one of the Yorkshire Ridings, much remains to be done even here, and mainly for two reasons. First, the books published deal in the great majority of cases with only a small proportion of the names that call for explanation. Secondly, quite apart from any individual weakness or idiosyncrasy on the part of their authors, each of these books suffers from a weakness entirely beyond their control—viz., that it is impossible to deal satisfactorily with the evidence for any single county until that for all other counties is available also. For these reasons alone it is clear that much fresh work will have to be done on these counties before anything like finality can be attained, and there are still some eighteen counties and two-thirds of Yorkshire untouched.

For the proper treatment of the old and new areas alike, new and extended lines of work are gradually suggesting themselves. In the first place, a much more thorough and exhaustive study than has hitherto been attempted must be made of local pronunciations, so far as they have survived. Often the ultimate solution of the history of a place-name depends upon a knowledge of such a local pronunciation, and it is becoming increasingly hard to discover the existence of such. False ideas of what constitutes an educated way of speech in this matter are tending to drive them out in favour of forms based on the written word. Here much help may be obtained from a study of sixteenth, seventeenth, and eighteenth century Parish Registers, many of which have been reprinted, and many more of which are available in typewritten or MS. transcripts. Luckily for us, the average parson of those days did not travel far, could not study ordnance maps, and was not a pedant in matters of spelling. When a marriage took place at Corbridge, and the bridegroom came from Alnham, the Vicar wrote what he heard, viz. that the bridegroom came from *Yeldham*; or when a child born at Coniscliffe was baptised at Newcastle, his birthplace was recorded as *Cunsley*. Again and again the first trace of such local pronunciations has been found in entries such as these and suggested grounds for further inquiry. That the ultimate solution of a name may often depend on a knowledge of such a pronunciation may be illustrated from the history of *Haltwhistle*. From 1240 onwards we find spellings such as *Hautwisel*, *Hawtetwysill*, and it is not till 1479 that we find one with *l*, such as *Haltewesyll*. This completely puzzled the present writer until in the Corbridge Parish Register for 1655 he came upon the form *Hoatewhisle*. This put him on the track of the still existing local pronunciation, " Hoatusle," and it was at once clear that here, as in Ault Hucknall, Derbyshire, the first element is Old French *haut*, high, with later intrusion of *l*, due to learned folk who knew its connection with Latin *altus*. Soon, as in the common word *fault*, earlier *faute*, the new spelling form prevailed, and, except on the lips of the people of the countryside, ousted the linguistically correct form. *Haltwhistle* is " the high ground at the *twisle* or forking of Haltwhistle Burn and South Tyne."

For these reasons it is much to be desired that all existing records should be ransacked for such phonetic spellings, and that those who have had the requisite phonetic training should, in the course either of their work or play, make note of all local pronunciations with which they come in contact, and get them placed on exact record before it is too late.

Further, England is incomparably rich in historical documents which provide early forms for the study of place-names. For our Old English charters we are still almost entirely dependent on the eminently unsatisfactory editions of Kemble and of Birch. The fact that there is no good edition is not, however, any excuse for the comparative neglect of these fundamental documents by many of our writers on place-names, and it is sincerely to be hoped that ere long those possessed of the necessary philological and palæographical knowledge may give us the editions we so sorely need.

The lengthy series of *Calendars of Charter Rolls*, *Patent Rolls*, and other documents issued under Government authority are unluckily marred, especially in the earlier volumes, by lack of local topographical knowledge. Students of local history working through these volumes could do much to help the writers on place-names by tackling the problem of the identification of many of them. The indexes of these volumes are full of unidentified names and of names that have been wrongly identified.

Finally, one of the great difficulties in English place-name study is the fact that we have to deal with names given by a succession of settlers of varying race and language. Knowledge is needed not only of English in all its stages of development, but also of Anglo-French and of the various Scandinavian and Celtic languages. No single scholar can hope to deal with all these problems. Hitherto a certain amount of help has been received from specialists in Anglo-French and Scandinavian, but no one has attempted to deal with any of the Celtic problems which clamour for attention, except Ekwall, in his recently published *Scandinavians and Celts in the North-West of England.* At present writers on place-names must of necessity either omit these difficult names altogether, or give their forms with no word of comment of explanation.

Such are three only of the many new vistas of study which open up before us if we once begin to think how to carry through the work that still remains to

be done, and the lesson to be drawn from them all is how hopeless is the future of place-name study in England unless we secure some measure of co-operation and co-ordination in its future conduct. If left to himself the scholar will continue his more or less haphazard methods of selection and treatment, and no scholar working by himself can hope to compass the necessary study of the place-names of England as a whole. For the collection of local forms, the critical study of Old English charters and documents generally, for light on problems in those languages with which he is not familiar, he must have at his command channels of information with which he can at present only get into touch, if he does so at all, with much trouble and a good deal of luck. The how, the when, and the where of such co-ordination and co-operation cannot be discussed here. For the moment let us realise its necessity if the study of English place-names is ever to become in the fullest sense of the term " scientific."

The chief books on single counties are published as follows:— The Cambridge University Press: Goodall, *Place-Names of South-West Yorkshire*; Mutschmann, *P.N. of Nottinghamshire*; Roberts, *P.N. of Sussex*. Oxford University Press: Skeat, *P.N. of Berkshire*; Alexander, *P.N. of Oxfordshire*. Milford: Duignan, *P.N. of Staffordshire, Worcestershire, and Warwickshire*. Manchester University Press: Sedgefield, *P.N. of Cumberland and Westmorland*. Constable: Wyld and Hirst, *P.N. of Lancashire*. Bellows, Gloucester: Baddeley, *P.N. of Gloucestershire*. Skeat's volumes on *Cambridgeshire, Bedfordshire, and Suffolk* were published by the Cambridge Antiquarian Society, and can be purchased through Messrs. Deighton Bell or Messrs. Bowes & Bowes. His notes on *Huntingdonshire* are to be found in vol. x of the same Society's *Communications*. His *P.N. of Hertfordshire* was published for the East Herts Archæological Society by Stephen Austin & Sons, Hertford. Moorman's *West Riding Place-Names* formed vol. xlviii of the publications of the Thoresby Society. A book on the *P.N. of Northumberland and Durham* by the present writer is now at press at Cambridge. Stenton's *Essay on the P.N. of Berkshire* is published by University College, Reading; and Walker's "P.N. of Derbyshire" appeared in the *Journal of the Derbyshire Archæological and Natural History Society* in 1914 and 1915.

In Sweden have been published: Ekblom, *P.N. of Wiltshire* (Appelberg's Boktryckeri, Uppsala); Lindkvist, *Middle English P.N. of Scandinavian Origin*, Part I (Akademiska Bokhandeln, Uppsala); Zachrisson, *Anglo-Norman Influence*; and Ekwall, *Scandinavians and Celts* (C. W. K. Gleerup, Lund). All these are written in English.

Excellent introductions to the study of personal names will be found in Weekley's *Romance of Names* and the same author's *Surnames*.

Psychology from the Standpoint of a Behaviorist. By PROF. JOHN B. WATSON. (Lippincott, 10*s*. 6*d*. net.)

The Wireless Transmission of Photographs. 2nd Edition. By MARCUS J. MARTIN. (Wireless Press, 5*s*.)

Selected Studies in Elementary Physics. By E. BLAKE. (Wireless Press, 5*s*.)

Musical Sands

By Cecil Carus-Wilson, F.R.S.E., F.G.S.

For some centuries past travellers and others have referred from time to time to the existence of sands which, under favourable conditions, produce mysterious music, and many of these references may be found in my paper on "Musical Sand," read before the Bournemouth Society of Natural Science in 1888.

Up to 1850, when Hugh Miller discovered musical sand at the Isle of Eigg, there were but two other generally well-known localities where these sands occurred. These were Jebel Nagous, or "Mountain of the Bell," in the desert of Mount Sinai, and Reg Ruwan—or Rig-i-Rawan—the "Moving Sand," about forty miles north of Corbul.

The former had been visited by Seetzen in 1812, and by Gray, Ehrenberg, Wellsted, Newbold, and others subsequently, and the latter by Sir Alexander Burns in 1836.

Since Hugh Miller's time, however, musical sands have been found on beaches at many places. Professor Bolton and Dr. Julien, through the Smithsonian Institution in 1884, recorded their occurrence at no less than seventy-four localities on the Atlantic coast of the United States. Since discovering these sands at Studland Bay in 1888, I have found them at many places, and other observers have also added to the list.

My observations and researches have been carried out with the musical sands found on sea-beaches and those produced artificially in the course of my investigations only, since I have been unable to visit any of the desert examples referred to.

Lieutenant Newbold visited Jebel Nagous in 1840 and made some most interesting observations. His Bedouin guide ascended the slope, and the loose sand thus set in motion produced "a faint musical sound resembling the deeper chords of a violoncello at a distance." Newbold and his friend Mr. Shute then climbed up the face of this loose sand and seated themselves "at the base of the mural cliffs which crest the summit," and from this point they watched the sand they had set in motion roll down the slope "in gradually widening lines to the base." "The disturbance of the upper layers of sand went on increasing on every side, somewhat resembling the effect produced on the surface of still water on dropping a stone into it. . . . About two minutes after the sand had first been set in motion a faint rustling sound, as it rolled down, struck our ears; then the low, deep, distant, musical tone we had first heard, which generally became more and more distinct, and apparently nearer, in successive and fast-repeating notes, whose sound partook of those of a deep, mellow church or convent bell, and of the vibrations of a stringed instrument." Newbold then disturbed the sand near the summit with his feet, and the notes became higher and more prolonged, "resembling the wild strains of an Æolian harp, but gradually becoming deeper and louder, until at length they rivalled the continued rumbling of distant thunder," and caused the sand on which they sat to tremble in distant vibrations. The sensations experienced were similar to those one might expect to feel if seated on the body of some gigantic stringed instrument while the bow was being slowly drawn across the strings.

Newbold's opinion on the cause of these remarkable effects concided with that of Lieutenant Wellsted, a former observer in 1830. They believed the sounds were due to the action of the wind upon the waves of sand as they flowed down the slope. In my paper of 1888 I showed that this explanation was untenable.

In 1889 Professor Bolton visited Jebel Nagous, and made observations which were graphically described in a paper read before the American Association for the Advancement of Science.

As one might have expected, similar sounding sands occur in other parts of the desert where the same conditions prevail, and Professor Bolton discovered another example which Dr. Julien named "Bolton's Bell Slope." In 1912 Mr. Harding King referred to similar phenomena occurring in the Libyan Desert.

Another noted example is the El Bramador, or "Roarer or Bellower," in Chili, mentioned by Darwin in 1835, and described by Mr. M. H. Gray in *Nature* in 1909. The "Barking Sands" of the Hawaiian Islands are also well known.

It would appear from these, and many other references which it is unnecessary to give now, that the effects produced by the accumulations of loose sand are similar in all cases, and differ materially from the sounds emitted by the musical sands of beaches when struck or agitated by artificial methods.

Describing the musical sands of Eigg, Hugh Miller wrote: "I struck it obliquely with my foot, where the surface lay dry and incoherent in the sun, and the sound elicited was a shrill, sonorous note, somewhat resembling that produced by a waxed thread when tightened between the teeth and the hand and tipped by the nail of the forefinger."

In 1884 Professor Bolton and Dr. Julien conducted some interesting experiments on the "singing beach" at Manchester-by-the-Sea, Massachusetts, with a view of arriving at some definite conclusion in regard to its peculiar characteristics.

Hugh Miller found that the loudest sounds were produced by drawing the hand slowly through the incoherent sand on the beach at Eigg, while Professor

Bolton thought they were produced by placing about a quart in a bag and striking it, the sounds thus elicited being heard at a distance of 450 feet.[1]

Professor Bolton and Dr. Julien published a theory to account for the cause of the phenomenon. They believed that the individual grains of sand were surrounded by films of condensed air, and that these acted as elastic cushions, enabling the grains to vibrate separately when disturbed. Thus they would behave like microphonolites when struck; but there are many insuperable objections to this theory.

In 1886 I commenced my investigations with a view to discovering the cause of the sounds, and was finally led to believe that they were due to the rubbing together of millions of clean and incoherent grains of quartz, with no angularities, roughness, or adherent matter investing the grains; and that, though the vibrations emitted by the friction of any two grains might be inaudible, those issuing from millions, approximately of the same size, would give an audible note. Working on this supposition, I produced in 1891 notes from a treated sand that was not previously musical.[2]

The highly musical Eigg sand can be rendered mute by adding a certain quantity of dust or purely angular grains, and certain mute sands may become musical by eliminating dust or angular grains. Again, completely spherical grains will not produce music.

After all, it is the proportionate presence of the different mineral fragments that decides the purity and intensity of the notes, other conditions being favourable. We can easily suppose that sand possessing all the necessary conditions in great perfection will be most musical, while those sands possessing all, or some, in less degree, will emit sounds decreasing in musical qualities in proportion to the decrement of the essential factors, severally or in combination.

Sound is the result of a series of pulsating waves of air, or vibrations, which impinge upon the tympanum or drum of the ear successively. When these vibrations are irregular we get noise; when they succeed each other with sufficient rapidity, and at regular intervals in a given period of time, the noise becomes music.

If we take a sand composed of quartz and other grains which are more or less angular, and vary considerably in size, and strike it in a cup with a wooden plunger, we get *noise*. But a musical sand composed chiefly of quartz grains which are more or less rounded and sub-angular, are well polished, and vary but little in size, when struck in the same way produces *music*. In the first case we get irregular vibrations, and in the second case regular vibrations.

[1] Some of my own observations and experiments at Eigg were referred to in *Nature*, June 15, 1911.

[2] *Nature*, August 1891.

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Now as to the origin of these regular vibrations from sand grains: If we draw the point of a pen vertically over the surface of a piece of glass, friction puts a drag on it and tends to stop its progress. But the point meets the increasing obstruction by finally jumping over it, so that it progresses by means of a series of regular "running jumps," so to speak, and these give rise to the regular vibrations that produce the squeaks emitted.

If we increase the number of steel points we increase the volume of sound.

Now let us suppose that a number of sand grains, complying with the requisite conditions, rub against each other when in motion, and produce a number of vibrations of equal length. They would then produce a musical note.

The quality and intensity of the notes emitted by musical sands depend largely upon the shape and composition of the receptacles in which they are tested. A porcelain cup gives good results, but when the same sample is similarly treated in a flower-pot, a cardboard box, or a rubber vessel, it is practically mute. Pour it back into the porcelain cup and it is as musical as ever! We may assume that these remarkable results are due to the fact that in experimenting with small quantities of sand their efforts to produce music need assistance. This they obtain when the grains move freely against the sides of glazed porcelain or smooth wooden vessels. They possess greater mobility in such vessels. In the case of a flower-pot, box, and rubber receptacle, these encouraging factors are absent. Compression, too, produces compaction, and therefore loss of coherency in the sand. As the flower-pot is smaller at the bottom than at the top, the sand is compressed when struck, thus depriving the grains of the freedom to move one over the other.

Coherency is also destroyed by wetting. Sand that is quite musical when dry may be rendered mute by wetting.

In regard to the plungers: Some are good for the purpose required and others bad. A beech-wood ninepin, a deal paint-brush handle, and a glass pestle, are good. Rubber, cork, and lead are bad. I call these positive and negative plungers. Some cylinders, such as glass and metal, are positive, and some negative plungers will give feeble results on a fresh patch of musical sand *in situ*.

A positive plunger may be rendered negative by covering the striking end with rubber. A negative plunger may sometimes be rendered positive by what I call "coaxing." Thus, a negative cork will become positive if we screw a porcelain knob into one end. Also, a negative cork may produce positive results if fixed in the end of a piece of one-inch iron piping.

I have stated elsewhere that the pitch of the note produced by a plunger is determined by its bulk and the area of its striking surface. The striking surface of a beech-wood plunger nearly an inch in diameter, when plunged into the sand in a porcelain cup, emits a note of a certain pitch. A smaller plunger, having a striking surface of about half an inch in diameter, gives a note of much higher pitch.

With a rolling-pin and a large basin of musical sand we can produce a deep note like the baying of a large dog, and with a lead pencil a note like a shrill whistle.[1]

But it is important to observe that the pitch of a note may be varied at will by increasing or decreasing the bulk of the plunger. If we screw a brass knob on to the upper end of a plunger, the pitch is considerably lowered, though the area of the striking surface is unaltered.

I believe that the positive plungers vibrate in sympathy with the vibrations produced by the sand grains, and, acting as resonators and intensifiers, are responsible for the greater part of the sound we hear. The late Professor Poynting, who took considerable interest in some of these experiments, thought so too.

Thus the pitch of a note does not depend only upon the area of the striking surface, but rather upon the size or bulk of the plunger, other things being equal.

A large plunger vibrates less rapidly than a small one, and so produces lower notes. We may use a plunger which, if vibrating, would always emit a constant note. At one end we may have a large surface, and at the other end a small one. But whichever end is used for striking the sand, the pitch of the note remains the same. A plunger made to fit together in two parts acts in the same way.

Another curious fact is that if we take two positive plungers, giving a low note and high note respectively, and strike the sand with both simultaneously, no note is produced.

This is probably due to interference setting up general confusion in the vibrations, and so destroying the usual effect, which appears to suggest that it is the plungers rather than the receptacles which act as resonators.

[1] See *Nature*, July 15, 1909.

Wireless Telegraphy and Telephony. By H. M. Dowsett. (Wireless Press, 9s.)

Practical Zoology. By Prof. Marshall and Dr. Hirst. 9th Edition, revised by Prof. F. W. Gamble, F.R.S. (John Murray, 12s. net.)